

# **PAINT AND SURFACE PREPARATION**

**A  
TRAINING  
PROGRAM  
FOR  
SHIPYARD  
PERSONNEL**

**NAME \_\_\_\_\_  
SHIPYARD \_\_\_\_\_**

**A project of the National Shipbuilding Research Program**

**U. S. Department of Commerce  
Maritime Administration  
in cooperation with  
Avondale Shipyards, Inc.**

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## FOREWORD

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Paint and surface preparation have become increasingly important to the American shipbuilding industry. Paint department costs are now the third largest item in new ship construction. Costs have increased and coating technology has become very complex. New equipment, materials, techniques of surface preparation and paint application have become highly specialized. In addition, drydocking times have increased and surface treatments are expected to last longer. Developments and improvements in this industry have an effect on production and maintenance costs, which in turn have an effect on existing and future jobs. The American shipbuilding industry must keep up with improvements overseas and remain competitive by reducing waste and keeping costs down.

Because of this, the U. S. Government has developed this training program to help you in learning and upgrading your knowledge and skills in surface preparation, paint handling, and paint application making up the total painting/coating job. Because there is a lot of information to learn and remember in order to do an effective job, this workbook is designed to help you review operations you are already familiar with and learn new techniques and practices before you have to put them into action. The objectives are to make the training consistent, to simplify your job and to make it safer. The material is presented in a logical order with step by step instructions and illustrations. As an aid to learning, you can refer back to various procedures for reinforcement of new information. A lot of space was left for you to make your own notes during training. This is your book - use it well.

The project was carried out under the National Shipbuilding Research Program, in cooperation with Avondale Shipyards, Inc., Mr. John W. Peart, Program Manager. Development work was accomplished under subcontract to the Lincoln Hall/Institute of Applied Technology, Mr. Jay I. Leanse, Executive Director, and Ms. Jess Gersky and Allyn Stanton, project directors.

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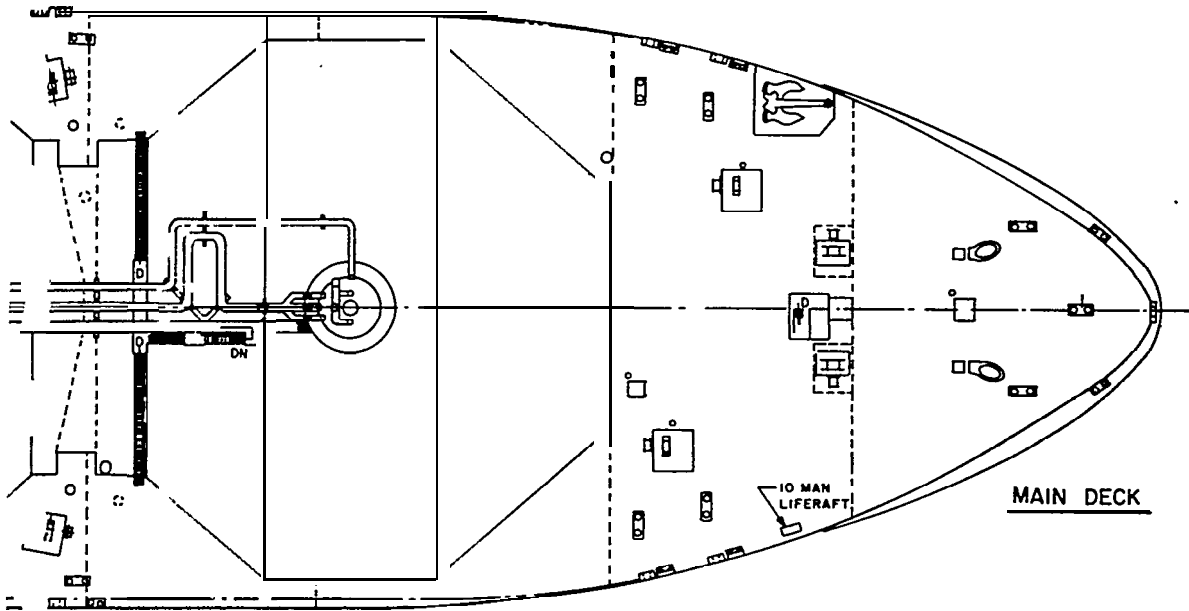
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# PART A

## MARINE COATING TECHNOLOGY



### UNIT I CONTROLLING CORROSION

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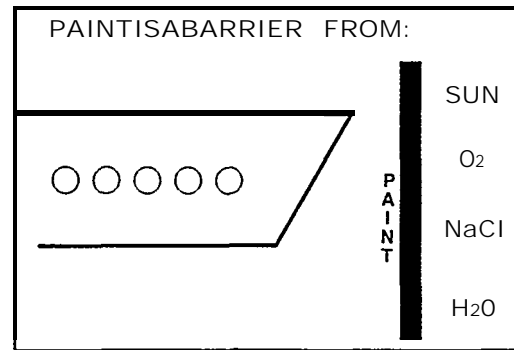
## CONTROLLING CORROSION

## WHY ARE SHIPS PAINTED?

Painting a ship serves many functions:

Ž Preservation of the surface

"Save the surface and save all." Once the steel surface of a ship begins to rust, the entire structure is in danger of widespread corrosion. Paint creates a protective film against deterioration and corrosion.



- Safety Markings

Colors are universally used for quick identification in an emergency:

Red = fire protection equipment

Yellow = caution/physical hazard

Green = safety equipment

Ž Fire Retardation

Certain paints can delay the spread of fire and are used in the ship's living quarters to provide an extra margin of safety.

- Anti fouling

The growth of marine organisms on the ships underwater hull causes drag which can require 10-20% more fuel to maintain design speed. At today's fuel prices, the use of anti fouling paint to control barnacle growth is an enormous cost saving.

- Identification Markings

- Non-Skid Deck

Ž Noise Control

Ž Decoration

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## HOW IMPORTANT IS CORROSION CONTROL?

Corrosion control is a very important factor in terms of marine economics and safety. Corrosion is responsible for:

- interrupted service time
- high maintenance costs
- costly repairs
- cargo contamination
- safety problems
- loss of mechanical properties
- unsatisfactory appearance



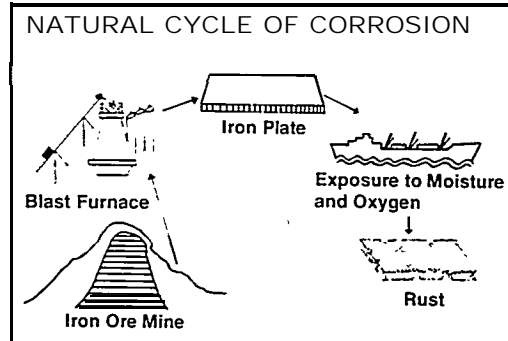
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## WHAT IS CORROSION?

Corrosion is the process which causes a metal to rust. Although corrosion is destructive to the metal, it is a natural process and all metal will corrode over time.

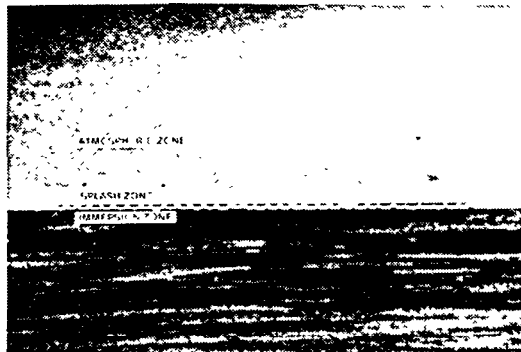
Iron and steel do not occur naturally. They are extracted from iron ore in a blast furnace process at very high temperatures. In the process of being converted into iron or steel, the ore acquires large amounts of energy. A metallurgist would say that it is made "unstable" in the process. Its natural tendency is to "stabilize," to shed or release the acquired energy. During the release of energy, the iron or steel corrodes and rust is formed.

Chemically, rust is the same as iron ore. Both are made of iron and oxygen; both are iron oxide. The process of corrosion can therefore be viewed as a cycle of nature.



WHERE DOES CORROSION OCCUR ON A SHIP?

Corrosion can occur everywhere on a ship. There are three distinct corrosion zones:

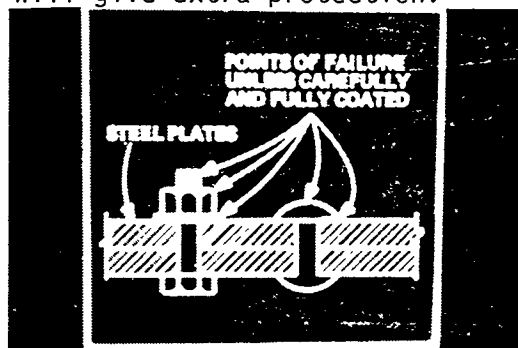


- **Immersion Zone.**  
The ship's underwater hull is constantly immersed in sea (salt) water. Man-made pollutants, including oil and chemical spills also attack the steel.
- **Splash Zone.**  
The zone above the water line is exposed to salt spray, humidity, foul weather and the sun's rays which break down the paint film.
- **Atmosphere Zone.**  
Superstructure, such as stacks, masts, spars, radar and sonar devices are also exposed to the weather, salt spray and ultra violet rays, and to the fumes and gas which condense on their surfaces.

CONDITIONS WHICH  
ACCELERATE CORROSION.

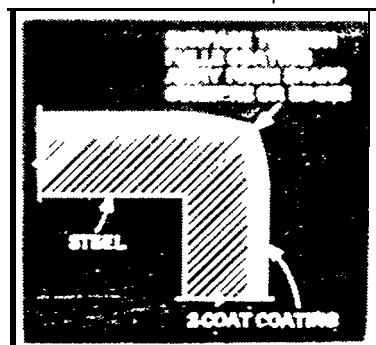
A. Lap welding creates crevices which trap moisture and pollutants and increase the chance that rusting will occur.  
ACTION: Work the paint into gaps with a brush.

B. Riveted areas must be free of gaps. Caulking is used to fill-in pockets which cannot be reached with coatings.  
ACTION: Additional coats of paint brushed onto rivet edges will give extra protection.



C. Skip welding, or intermittent welding, leaves pockets which tend to corrode faster than flat surfaces because of the dirt and water which collect there.  
ACTION: Caulk whenever possible and work paint well into the gaps with a brush.

D. Sharp edges on a structural steel member promote corrosion because the paint draws thin at the edge, wears away, and exposes bare steel.  
ACTION: Round the edges to relieve sharpness and stripe with an extra coat of paint.



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HOW DOES PAINTING  
CONTROL CORROSION?

There are two primary ways that paint protects steel:

1. A coat of paint acts as a barrier between the metal and the corrosive elements.

To separate the steel from water and oxygen the paint film must be:

- Relatively Impermeable.  
If moisture and oxygen pass through the paint film, rust may form and lift the coating from the surface.

• Tightly Adhered to the Surface.

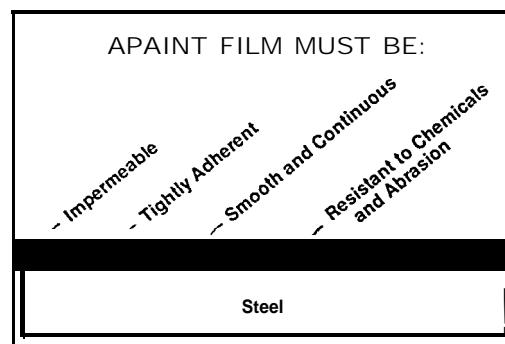
A coating must form a tight membrane over the surface with no area underneath the film to collect moisture.

• Smooth and Continuous.

The paint film must be applied evenly and must be free of small skips, or pinholes which will allow water and oxygen to enter. A tiny spot of corrosion may spread quickly under the paint, stretching, cracking and lifting the film as it progresses.

- **Resistant to Chemicals and Abrasion.**

Paint must resist chemicals in the air, sea water, or carried in the ship's tanks. It must resist scratching from dropped tools, movement of men and equipment, or knocking against a pier.



2. A second way in which paint can help to control corrosion is through protective pigments.

• Zinc rich paints are a prime example.

The zinc dust corrodes while the surface remains unharmed by corrosion. Over time, the zinc will disappear leaving the steel unprotected. For this reason, zinc paints are usually used as primers and require a topcoat for barrier protection.

## PROPERTIES OF SHIPYARD PAINTS

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**HOW DOES A PAINT ACQUIRE STRENGTH AND PROTECTIVE PROPERTIES?**

Years ago, paints were relatively unsophisticated blends of natural oil and pigment. They all had similar properties and were easily thinned with one or two types of solvents. Today, the range of raw materials which go into paint is staggering. A manufacturer may have to stock 500-600 different chemicals in order to produce a full paint line.

These new carefully formulated paints are expensive, \$25.00 per gallon for aliphatic urethane versus \$7.00 per gallon for alkyds. If they can give maintenance free performance over the years, however, this more than compensates for their high initial cost.

Because of the many chemicals used to achieve the desired properties, these new paints are sensitive. They must be mixed and used with care.

A complete paint is composed of three parts:

Resin or Binder. This is the film forming, or solids portion of the paint. It remains on the surface once the solvent has evaporated. Paint types take their name from the resin: alkyd, vinyl, urethanes, etc.

Solvent. The function of the solvent is to dissolve the resin for easy application. The drying time and flowability (viscosity) of the paint are effected by the type of solvent used.

Pigment. Pigments primarily provide hiding power, color, and resistance to weathering. They are solids and form part of the paint film.

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**COMMON MARINE PAINTS AND THEIR USE.**

A. ALKYD. Alkyds have been called the "workhorse of the coatings industry" because they are the most widely used. Alkyd is a synthetic resin which is modified with oils. The oil allows alkyd paints to penetrate the steel surface irregularities and to adhere well.

Use: In marine work, alkyds are often applied above the water line, but they are unsuitable for use underwater.

Surface Preparation: Tolerant of hand and power tool cleaning

Method of Application: Brush, roller, spray

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Solvents: Mineral Spirits, VM&P Naphtha, Xylol

Other Characteristics: Easy to apply; moderate gloss and color retention; may be applied to relatively low temperatures.

B. BITUMINOUS. Bituminous coatings -- asphaltic and coal tar pitch materials -- are widely used in highly corrosive atmospheres and where the black color is not a problem. Coal tar pitch is superior to asphalt as a water barrier, but it gets brittle when exposed to air, heat, and sunlight.

Use: On ship bottoms where impermeability is important, Bituminous coatings are often used. They are also **applied** as anticorrosive paints in ballast tanks and chain-lockers.

Surface Preparation: Commercial blast for immersion service. For recoating, fresh water wash, scraping, and power tool cleaning of bad areas is acceptable.

Method of Application: Brush, roller, spray

Solvents: Aromatics, Mineral Spirits

Other Characteristics: May be applied on top of most other paints without risk of lifting undercoats; easy to recoat; good wetting properties.

C. CHLORINATED RUBBER. Chlorinated Rubber is made by exposing natural rubber to chlorine gas. The resin which results is outstanding in its resistance to water and common corrosive chemicals. It is a good water vapor barrier and resists strong acids, alkalis, mineral oils, mold and mildew. It is odorless, tasteless, non-toxic and non-flammable.

Use: Chlorinated Rubber may be recommended for all exterior ship areas: bottom, boottop, weather deck and superstructure. It is relatively quick drying -- it may be dry to touch in 30 minutes. Full cure usually requires 4-8 hours.

Surface Preparation: Power tool cleaning or spot blasting for recoating; near-white blast is recommended for immersion service.

Method of Application: Spray, brush

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Solvents: Xylene, Toluene

Other Characteristics: Easy to recoat, good gloss, and color retention; applicable at low temperatures; low film build per coat.

D. EPOXY. Epoxy resin is found in a large group of epoxy coatings which are widely used in shipyards because they have a combination of many desirable properties: excellent adhesion, durability, and chemical resistance. Epoxies are two-package, or catalyzed, paints. The three types of catalysts are: polyamine, amine adduct, and polyamide. Coal-tar epoxy is a blend of coal-tar pitch and epoxy resin.

Use: Amine cured, polyamide cured, and coal-tar epoxies are used on shipbottoms. Epoxy polyamide may also be specified for boottop, weather deck, superstructure areas, and on the inside of oil, water, and chemical tanks.

Surface Preparation: White metal blast for immersion service; a near-white blast is required for good adhesion in new construction. In M & R, spot blasting or power tool cleaning is acceptable.

Method of Application: Spray, brush

Solvents: MEK, MIBK, Xylene, Toluene

Other Characteristics: Good chemical and oil resistance; some epoxies may be applied under water; hard and slick film with excellent adhesion.

E. INORGANIC ZINC. Inorganic zinc-rich coatings consist of at least 80% zinc dust which is dispersed in the vehicle portion. Zinc dust has very good hiding power. It is used to inhibit corrosion, serving as a sacrificial material -- the steel is protected at the expense of the zinc.

Use: Inorganic Zinc is used on weather decks, the superstructure, and on off-shore structures.

Surface Preparation: Near-white or white metal blast is required

Method of Application: Spray application only

Other Characteristics: High resistance to heat; provides "galvanic" protection to metals; constant stirring necessary to keep the zinc dust evenly dispersed.

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F. POLYURETHANE. This is one of the newest man-made resins used in coatings today. Polyurethane resin is used in a wide range of coatings, - from hard glossy enamels to soft flexible coatings and insulating foams.

Use: Polyurethane coatings are suitable for use on tanks and in the boottop, topside, weather deck and superstructure areas.

Surface Preparation: Near-white blast is recommended for new construction; power tool cleaning is acceptable for recoating

Method of Application: Spray, brush

Solvents: Ethyl or Butyl Acetate, MEK, MIBK

Other Characteristics: Polyurethane can be applied at low temperatures, have excellent gloss retention and are highly resistant to chemicals and solvents. They may be difficult to apply and may produce strong toxic reactions in some painters.

G. VINYL. Vinyl coatings are widely used. They have excellent durability and resistance to acids, alkalis, chemicals and seawater, and they will not support combustion.

Use: Vinyls are commonly used in coating marine equipment. When coal-tar pitch is added to vinyl (vinyl coal-tar), additional underwater protection is provided for a shipbottom. Vinyl acrylics may be applied to the boottop, weather deck, - and superstructure areas.

Surface Preparation: Near-white blast is recommended for new work

Method of Application: Spray is recommended

Solvents: MEK, MIBK

Other Characteristics: A prime coat is usually required; may be applied at low temperatures; gloss retention is improved with the addition of acrylic resins.

H. ANTI-FOULING. Anti-fouling paints are used on shipbottoms to inhibit the attachment of barnacles, grass, algae and other marine growths. Cuprous oxide, a biotoxin, is the major anti-fouling ingredient in the various

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coatings which are used on ship bottoms -- bituminous, vinyl, vinyl pitch, epoxy, coal-tar epoxy, chlorinated rubber and flake glass. Organotin compounds are also used as toxic substances. Cuprous oxide provides exceptional resistance to shell fouling; resistance to the growth of weeds and grasses is boosted when organotins are added.

## ACHIEVING THE MAXIMUM PAINT SERVICE LIFE

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**HOW TO READ A  
MANUFACTURER'S DATA SHEET**

High performance paints require special handling to achieve the excellent performance promised by the manufacturers. The painter, therefore, must be familiar with each product's characteristics, special properties, and mixing and application requirements.

The manufacturer's data sheet, or product data sheet, contains information essential for equality application and safe use. Studying it before beginning the job will reduce paint failures and the need for rework.

Refer to the sample data sheet while reviewing the following terms and instructions.

**I & II-Description of the Paint**

This section provides basic information on paint type and areas of recommended use. If there is conflict between this data and what is called out in the specification, contact the technical representative for advice.

**III-Physical Properties**

% Volume Solids. Paint contains solids which form the dry film and solvents which are needed to make the material liquid during application. In order for the operator to set his speed and stroke, he must be able to calculate the expected dry film thickness (DFT) based upon his wet film (WFT) measurements. The relationship between DFT and WFT depends upon the paint's percent of solids by volume.

Viscosity. Viscosity describes a paint's consistency, how fast or slow it flows. Viscosity is specified as the length of time it takes for the paint to flow through a standard measuring cup at a certain temperature. Proper viscosity is important for good film build and ease of application.

Number of Components. The data sheet specifies whether the coating comes in one package, or two packages which must be mixed together. Be certain to have the proper number of containers at the job site.

Flash Point. The flash point of a paint is the lowest temperature at which the solvent releases enough vapor to ignite in the presence of a flame. This temperature is indicated in degrees Fahrenheit. The higher the temperature, the safer the paint is to use near an open

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flame. In some two-package paints, the flash point is different for each component.

Shelf Life. Shelf life is the length of time in which a paint may be stored at a given temperature and remain in usable condition. Cooler temperatures will increase the shelf life, whereas higher temperatures will severely shorten it. Minimum and maximum storage temperatures are also stated.

#### IV-Surface Preparation

To achieve good paint bonding, the surface must be properly prepared. This includes cleanliness as well as surface profile (see Part B, Unit I). The specific standards which must be met are indicated. Special instructions for primer and touch-up applications are also given by the manufacturer.

#### V-Mixing Procedure

For one-package paints, the data sheet will specify the type and amount of thinner to be used. Too much or the wrong kind of thinner will ruin a paint -- directions must be followed closely. Some paints cannot be thinned at all. They achieve their proper flowability by stirring. Follow directions closely.

For two-package paints, the data sheet will indicate the ratio of catalyst to base such as 1 part catalyst to 4 parts coating material. If the catalyst is pre-measured, that will be specified. Ratio information is essential for proper application and curing. The directions must be followed exactly.

The data sheet may also include instructions on mixing technique, when to add the catalyst, and how long to let the coating "sweat in" before application (induction time).

The term "pot life" applies to catalyzed two-package paints. It is the length of time in which the paint can be used once the components have been mixed together. It changes at different temperatures. Since the chemical reaction starts as soon as the two packages have been mixed, avoid mixing paint too long before it will be used. Paint that is allowed to stand beyond its pot life will cure in the container to a hard mass which cannot be sprayed.

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## VI -Application Procedure

The product data sheet will give the recommended application methods and required equipment. Often detailed information is given regarding the adjustment of spray equipment. A thorough data sheet will include the type of spray gun, the size of the fluid tip and air cap, ID of the material hose, and the pump pressure recommended for good results.

Environmental Limitations. Air temperature, surface temperature and humidity affect paint application and curing. The manufacturer will set limits for his product.

Dry Time. Dry times are expressed in hours at a certain temperature and humidity. Depending upon what operation is to follow the paint job, dry times may be expressed as:

1. dry-to-recoat time or intercoat dry time: the time elapsed before a second coat of paint may be applied.
2. dry-to-handle, the time elapsed before a surface or piece of equipment or modular unit may be touched or moved without damage to the coating, and
3. dry-for-immersion, drying time sufficient to allow for complete immersion such as floating a ship or filling a tank.

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### WHY IS CURING TIME CRITICAL TO A PAINT'S SERVICE LIFE?

Intercoat Curing. If the undercoat is allowed to cure too long, the topcoat will not adhere. The underfilm will be hard and smooth, leaving nothing for the topcoat to bit into.

If the undercoat is not sufficiently cured, blisters and lifting may occur as trapped solvents in the uncured undercoat try to escape.

Final Curing. Final cure must be obtained to achieve good bonding and full expression of the paint's protective qualities.

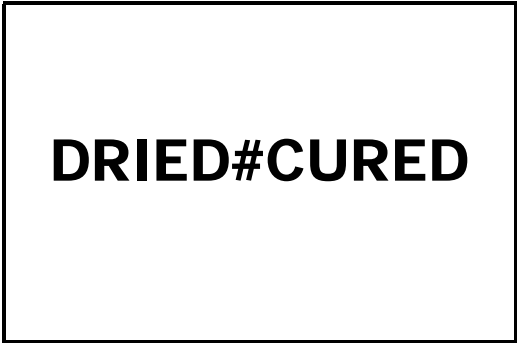
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WHAT IS THE DIFFERENCE  
BETWEEN "CURED" AND  
"DRIED"?

While these terms are often used interchangeable, they do not mean the same thing.

A dry film is one which is "dry to touch". When the thumb is pressed with moderate pressure on a dry film and rotated 90 degrees, the paint film will not sag, streak, or hold a thumbprint.)

A coating may be dry to touch but may not be cured. Only the surface has dried and the hard "skin" may have trapped solvents which can cause blistering. A cured coating is dry throughout and ready to perform its intended function.



DRIED#CURED

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WHY IS FILM THICKNESS  
IMPORTANT?

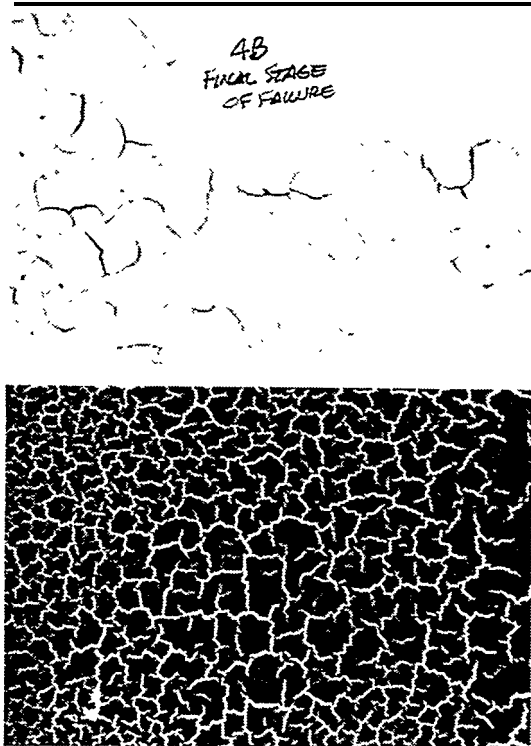
The thickness of the dried paint film is set by the manufacturer to provide the maximum protection to the surface.

If a film is too thin, it may:

- allow moisture to reach the metal
- expose high points in the surface profile causing pinpoint rusting
- **reduce the overall service life of the coating job**

If a film is too thick, it may:

- peel away from the surface
- mud-crack (especially zinc-rich paints)
- cure improperly (because it cannot dry internally) and blister or peel



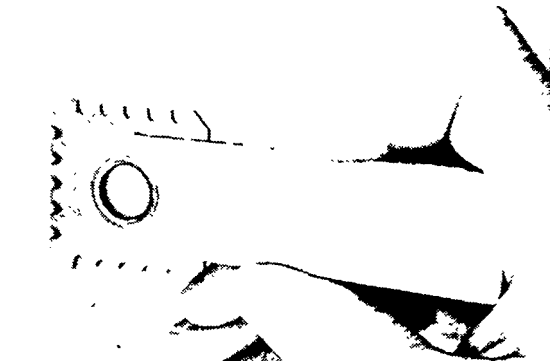
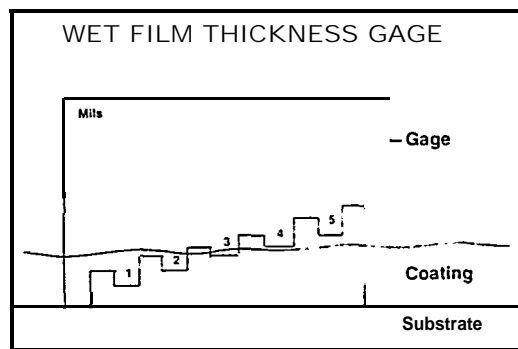
Coating thickness is measured in mils. One mil = 1/1000 of an inch. Because the mil is such a small measurement, it takes a great deal of skill to obtain the required thickness.

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HOW IS WET FILM  
THICKNESS MEASURED?

A painter must be able to adjust his equipment and the speed of his work to meet production schedules AND to achieve the correct film thickness. By taking wet film thickness (WFT) measurements as he applies the coating, he can predict the dry film thickness (DFT) and pace his work.

The WFT is easily measured using a wet film gage which looks like a comb with notches and legs of different lengths. Press the comb against the painted surface. Some of the legs penetrate the paint, while others do not. The WFT is a value between the first clean leg and the next lower, paint covered leg. In the illustration, the WFT is approximately 3.5 mils.



To measure WFT correctly:

1. Read WFT immediately after paint application before the solvents have evaporated.
2. Use the WFT gage on a flat surface. Both ends must be firmly touching the surface.
3. On a verticle surface, such as a bulkhead, hold the gage in a north-south position (verticle) with the longer legs at the top. This prevents the paint from running down over the longer legs and giving a false reading.
4. On a pipe, place the gauge along the length. Both legs must touch the surface.

- 
5. Lift the gauge from the surface without sliding. Slipping or sliding will give a false reading, extra paint will be picked up on the legs.
  6. Use only a clean, dry gauge. Clean the gauge after each reading. Dirt on the bottoms of the legs adds to their length and gives lower readings.

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HOW IS DRY FILM THICKNESS  
CALCULATED?

To calculate the expected DFT, you must have two pieces of information:

1. the measured WFT, and
2. the percentage of volume solids, as given in the supplier's data sheet.

To find the expected DFT, multiply the WFT by the percentage of volume solids. The formula is:  
 $DFT = WFT \times \% \text{ volume solids}$

Example. What is the DFT if a paint with 50% solids by volume is sprayed to a wet film thickness of 4 mils?

Step 1.  $WFT \times \% \text{ volume solids} = DFT$   
 $4 \text{ mils} \times 50\% = DFT$

Step 2. Convert the percent to a decimal:  
 $50\% \div 100 = .50$

Step 3.  $4 \text{ mils} \times .50 = 2 \text{ mils DFT}$

In this example, the DFT is one-half of the WFT. Half of the paint was made of solvents which evaporated, leaving a dry film with half the thickness of the wet film.

## FAILURE RESULTING FROM PAINT FILM DEFECTS

## CAN PAINT FAILURE BE PREVENTED?

All paints and coatings eventually deteriorate naturally. After several years of exposure to rain, sun, and weathering, even the best paints begin to fade, crack or peel. However, early costly paint failure can be prevented and the service life of a ship's coating can be extended, if attention is paid to:

- proper surface preparation
- proper paint selection
- proper paint mixing
- proper paint application
- compatibility of paints

The more sophisticated the paint, the more important these factors become,

## IDENTIFYING PAINT FILM DEFECTS

Defects in the paint film can appear immediately after a coating is applied, after curing, or after months or years of a ship's service. Film defects can lead to catastrophic paint failures and must be remedied before the surface is damaged.

Cratering, Pitting.

Appearance: Small uniform indentations in the film.

Cause: Air pockets trapped in wet film during application.

Remedy: Sand or blast to a smooth finish. Apply additional coats over the affected area.

Pinholing.

Appearance: A tiny but deep hole in the film where the steel or a preceding coat of paint is exposed. Pinholes on the primer can be detected with a special electric current instrument. They are too small to be seen with the unaided eye, but show up under 5-power magnification.

Cause: Insufficient paint atomized; coarse atomization; settled pigment.

Remedy: Brush pinhole areas and apply an additional coat of paint.

---

### Fish Eyes.

Appearance: Separation or pulling apart of the wet film. Previous finish or substrate can be seen in spots.

Cause: Improper surface cleaning; spraying over oil, dirt, silicone; incompatible coatings.

Remedy: Blast or sand, followed by a brush coat. Spray an additional coat over the area.



### Runs and Sags.

Appearance: Excessive flow of material causing slippage of paint and having the appearance of curtains.

Cause: Spray gun too close to work; too much thinner; too much paint applied; application over a hard or glossy finish.

Remedy: Brush out to remove excessive material before area becomes dry to touch. After runs and sags have cured, remove by sanding and apply an additional coat.



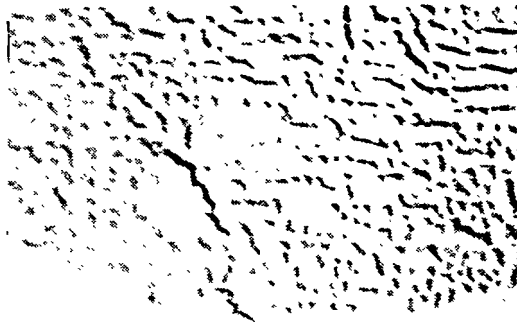
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### **Wrinkling.**

Appearance: Rough, crinkled surface.

Cause: Second coat dries before first; too much paint applied; application over glossy finish; painting in hot sun or over a too cold surface.

Remedy: Remove wrinkled layers by scraping or sanding. Repaint, avoiding direct hot sunlight or temperatures below 40 degrees F.



### **Overspray, Dry Spray.**

Appearance: Dry, flat, pebbly appearance.

Cause: Too rapid solvent flash-off -- particles reaching surface are not wet enough to flow together; paint particles fall to surface outside the spray pattern; gun held too far from surface.

Remedy: Before cure, remove by brushing with a dry brush followed by solvent wiping. After cure, sand and apply a second coat.



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### Dirt Under Finish.

Appearance: Foreign particles dried in the paint film.

Cause: Improper cleaning of surface or spray gun; dirty work area.

Remedy: In most cases, sanding and recoating is sufficient. Blasting may be indicated in extreme cases.



### Blistering.

Appearance: Small, swelled areas or broken edge craters.

Cause: Oil or moisture left on steel surface; improper undercoat or topcoat curing.

Remedy: For unbroken blisters, light sanding followed by repainting will correct the damaged areas. If the blisters have broken, apply an additional coat of paint.

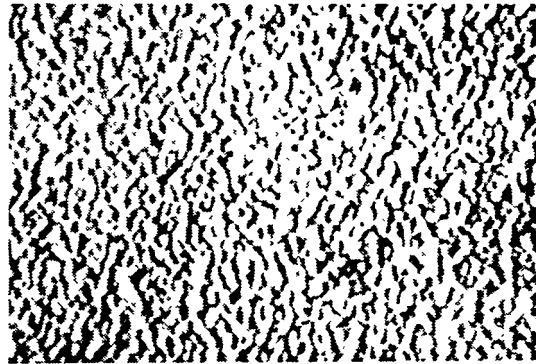
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### Orange Peel.

Appearance: Slight hills and valleys in the paint film, resembling the skin of an orange.

Cause: Air pressure too low causing improper atomization; material viscosity too high; solvent evaporates too quickly; gun too close to surface.

Remedy: Sand the area smooth and apply a second coat.



### Blushing.

Appearance: Finish is flat and has a milky appearance.

Cause: Fast thinners in high humidity; unbalanced thinners; condensation on old surface.

Remedy: Sand area and respray after adding retarder to the thinner used.

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### Fading.

Appearance: Color changes or irregularities.

Cause: Moisture behind paint film can leach the pigment; ultra-violet degradation.

Remedy: Repaint once the color has faded. Correct any possible sources of moisture.

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### Uneven Gloss.

Appearance: Non-uniform sheen, shiny spots.

Cause: Uneven film thickness; moisture in paint film and temperature variation during drying; painting over a paint film that is too wet or soft.

Remedy: Allow flattened paint to dry hard and apply another finish coat at a time when moisture is not present and temperature changes are less likely.

---

### Checking.

Appearance: Short, narrow breaks in top layer of paint.

Cause: Loss of paint film elasticity; excessive paint applied; surface or surrounding temperature too high during application.

Remedy: Remove paint down through the checked film and repaint.

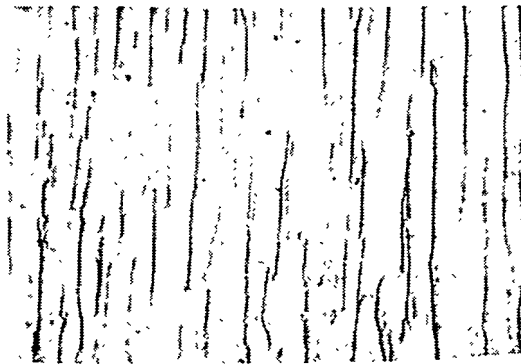


### Cracking.

Appearance: Deep breaks in the paint which may go down to the substrate.

Cause: Shrinkage of the film; excessive paint thickness (especially zinc-rich); improper exposure to high temperature or sun.

Remedy. Remove coating completely and repaint.



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Cobwebbing.

Appearance: Stringly, thin paint particles on the surface similar to "fingers" or "cobwebs".

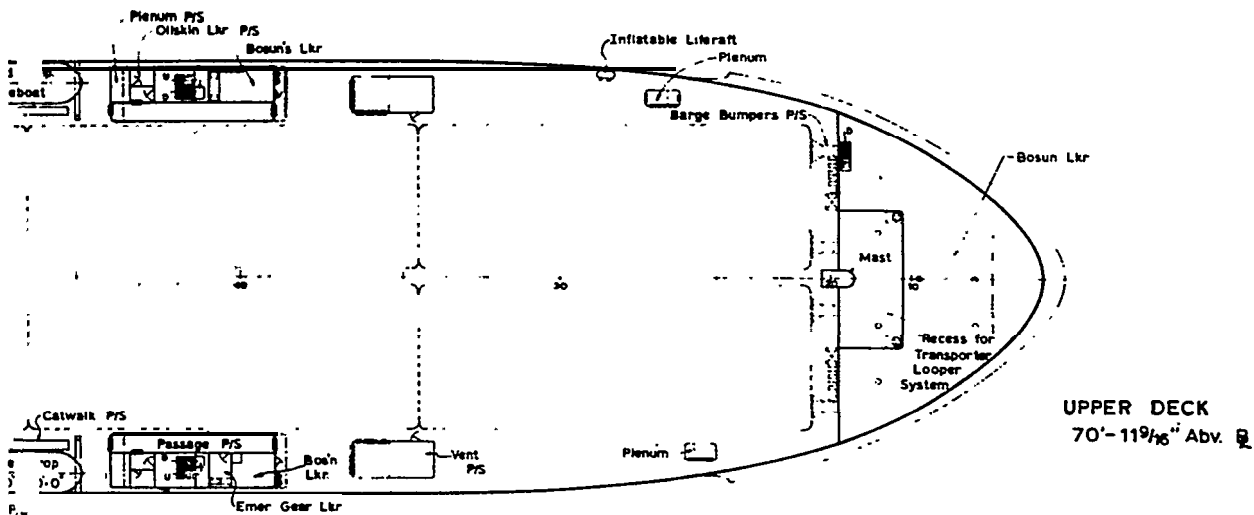
Cause: Solvent evaporates before paint is deposited on the surface most likely to occur when using paints with fast solvents, such as vinyl or chlorinated rubber.

Remedy: Use a slower solvent, especially in hot weather.



# PART B'

SURFACE PREPARATION:  
THE KEY TO  
COATING PERFORMANCE.



UNIT I  
IMPORTANCE OF SURFACE  
PREPARATION

UNIT II  
HOW TO CHOOSE THE PROPER  
METHOD FOR SURFACE PREPARATION

UNIT III  
EQUIPMENT SET-UP FOR  
NOZZLE BLASTING EFFICIENCY

UNIT IV  
EFFICIENT AND SAFE PRACTICES  
FOR SURFACE PREPARATION

## THE IMPORTANCE OF SURFACE PREPARATION

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**WHY MUST STEEL SURFACES  
BE CLEANED BEFORE PAINTING?**

Cleanliness is essential to prepare the surface to hold the coating. Paint applied over rust, dirt or oil will not bond to the steel. Early paint failure will result.

A clean surface is free from contaminants such as:

- . rust
- . flash rust
- . dirt and dust
- **salts**
- . oil and grease
- . dead paint
- **mill scale**

Rust cannot be penetrated by most paints. Painting over rust gives an uneven coating exposing metal to further corrosion.

Flash rust is a light layer of rust appearing on cleaned steel soon after exposure to the air.

Dirt and dust particles prevent the application of a smooth, uniform coat of paint.

Salts of various chemicals accelerate the rate at which corrosion will occur. Salts are likely to be trapped in pits and crevices and particular attention must be given to cleaning these areas.

Oil and grease prevent good paint adhesion and must be completely removed. Welding smoke and inspection markings leave an oily residue. Remove them.

Dead paint that is loose, cracked, or flaking will lift from the surface, cracking and peeling the topcoat.

Mill scale is a crust which forms on the surface of the steel as it is hot rolled. It has bluish, somewhat shiny appearance which may be difficult to see on new or partially blast cleaned steel. While difficult to remove, modern paints require the surface to be completely free of mill scale.

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On new steel, mill scale is tightly adhered to the surface.



After exposure and handling in the yard, the scale will begin to pop and rust will form on the surface.



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IS A CLEAN SURFACE A  
"PAINTABLE" SURFACE?

Not completely.

For new construction and maintenance and repair:

- weld splatter must be removed
- sharp edges must be ground off
- "tooth" or anchor pattern must be provided

For maintenance and repair:

- **thick layers of stiff paint should be removed**
- glossy paint surfaces should be flattened

For non-steel surface:

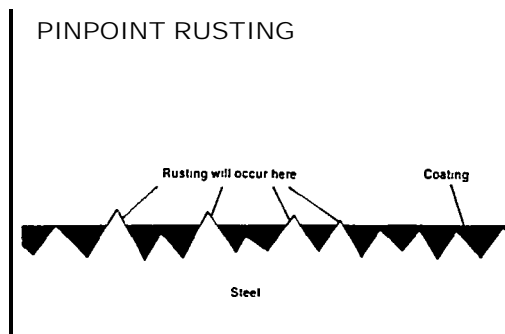
• aluminum and galvanized surfaces usually require special pre-treatment, decreasing and application of a wash primer

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WHAT IS ANCHOR PATTERN  
AND WHY IS IT IMPORTANT?

Anchor pattern, also called "profile" or "tooth" is a rough pattern of peaks and valleys which improves the ability of the paint to bond to the steel surface.

This pattern is obtained by abrasive blasting and must be carefully controlled according to the coating system being applied. If the peaks are too high, they will stick out above the coating film causing pinpoint rusting.



A good coating work procedure will tell you how high the peaks must be for that job. This height is measured in mils (.001 inches) and is controlled by the type, size, and hardness of the abrasive used.

A rule of thumb states: "The surface profile peaks should be approximately 1/3 of the required coating thickness."

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HOW CLEAN MUST THE  
SURFACE BE?

Written standards for blast cleaning define how clean the surface must be.

The standards have both names and code numbers which must be memorized and used.

Brush-off Blast Cleaning: SSPC/SP-7 or NACE 1

Definition:

- Totally remove: oil, dirt, rust scale, mill scale, loose paint.
- Permit tightly adhering mill scale, rust and paint if the blasting has exposed flecks of the underlying metal. These flecks must be uniformly distributed over the entire surface.

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Commercial Grade Blast Cleaning: SSPC/SP-6 or NACE 2

Definition:

- Ž Remove all oil, dirt, rust scale, rust and mill scale and old paint.
- Ž Slight shadows, streaks or stains from rust or mill scale oxide may remain. Slight rust or paint residue may remain in the bottom of the pits. At least 66 percent of each square inch of surface is free of all visible residues.

Near White Blast Cleaning: SSPC/SP-10 or NACE 3

Definition:

Completely remove all oil, dirt, mill scale, rust, paint or other foreign matter. Very light shadows or slight streaks or discolorations may remain. At least 95 percent of each square inch of surface is free of all visible residues.

White Metal Blast Cleaning: SSPC/Sp-5 or NACE 4

Definition:

Remove all foreign matter.

Note:

- Ž The surface has a gray-white uniform metallic color and is slightly roughened to form an anchor pattern.
- The color of the cleaned surface may be affected by the abrasive used.

## HOW TO CHOOSE THE PROPER METHOD FOR SURFACE PREPARATION

WHAT METHODS ARE AVAILABLE TO CLEAN THE SURFACE?

A variety of surface preparation methods are available to shipyards:

- **hand tool cleaning**

• **power tool cleaning**

• **solvent or chemical wash**

- steam cleaning

• **waterblasting**

- abrasive blast cleaning

### Hand Tool Cleaning

Types: Scrapers, clippers, rust hammers, chisels, knives

Use:

- **removal** of loose paint, layers of loose rust, dried soil

• **spotcleaning** small areas

- maintenance priming before applying bituminous and oleoresinous paints for atmospheric exposures.

Disadvantages:

- slow

- will not remove tightly adhered contaminants, dirt trapped in crevices, or oil and grease

• may raise burrs or dent the surface leading to paint failure.

### Power Tool Cleaning

Types: Wire brushes, sanding discs, grinders, clippers, scalers, needle guns, rotary descalers

Use:

- removal of loose rust and scale

- **preparation of heat damaged areas**

• preparation of post-erection welded surfaces

• removal of old paint lifted by rust

• suitable for small areas

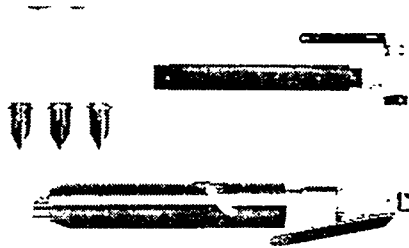
Disadvantages:

- **may create heavy surface indentations; use blunt needles**

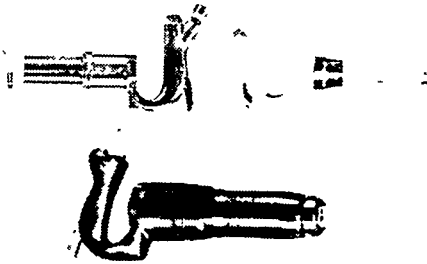
• **cannot completely** remove rust and scale

- may polish surface if used at too high speed or kept on one spot too long

## SCALERS



## CHIPPING HAMMERS



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## Solvent Washing

Use:

- removal of oil and grease
- **removal** dirt trapped in an oil film
- pretreatment before mechanical cleaning

Disadvantages:

• **no effect** on rust or mill scale

• slow; hand labor

• **rags** and solvent need constant replacement to avoid leaving an oily residue

## Steam Cleaning

Use:

- removal of dirt on top of existing paint
- effective on heavy soil; often commercial detergents are added

• cleans large areas more rapidly than solvent wiping



## Waterblasting

Use:

• removal of marine growth

- removal of loose paint, dirt and light rust (sand may be added to the water to improve cleaning)

Disadvantages:

- flash rusting
- water and sand mixture may be difficult to remove

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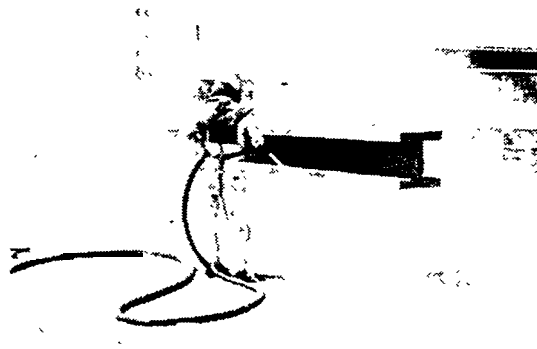
## Abrasive Blast Cleaning

Use:

- recommended when steel must be totally clean and exposed
- completely removes rust, mill scale and old paint
- creates a controlled anchor pattern

Types:

- nozzle blasting
- centrifugal or wheel blasting
- vacu-blasting



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## HOW TO CHOOSE THE RIGHT CLEANING METHOD

There are six factors to consider in choosing a cleaning method.

1. The major factor is type and amount of contaminant present.
2. The original condition of the steel. Fabrication, handling, and storage conditions of new steel may contribute to paint failure later on. Metal projections around edges, punched holes, weld splatter and chemical deposits must all be removed. The condition of old steel which may be badly scarred or pitted will also determine which cleaning method is chosen.
3. The type of paint applied, its wetting properties and surface profile requirements.
4. The size of the surface and structures to be cleaned.

5. The amount of working space and area set-up, including distance to machinery where grit and dust could ruin working gears and interfere with workers.
6. Legislation on safety, health, and environmental issues which may limit the discharge of dust and solvent emissions.

Cleaning Method	Contaminant
Solvent Cleaning or Steaming	Grease Oil Salt Weld marks Dirt
Waterblasting	Marine Growth Loose rust Loose Paint
Hand or Power Tools	Loose rust Weld splatter Loose mill scale Weld flux Loose paint

WHICH METHOD OF SURFACE PREPARATION IS IDEAL FOR HIGH PERFORMANCE COATINGS?

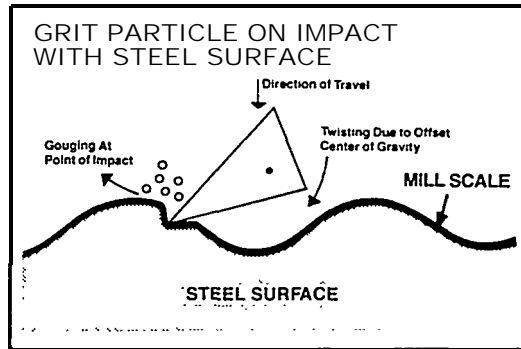
Abrasive blasting is the ideal surface preparation method for exotic paints and coatings which require anchor pattern and a high degree of cleanliness.

Blast cleaning is the only method which can completely remove intact mill scale and give an even roughness with a controlled anchor pattern.

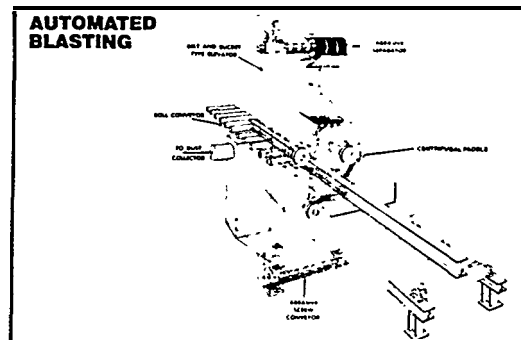
WHAT IS ABRASIVE BLASTING?

Abrasive blasting is the propelling (shooting) of sand or other types of small, hard particles at a surface in order to loosen and remove dirt, rust, and mill scale, and to create a good profile before applying paint.

In nozzle blasting, the force which propels the abrasive is compressed air. Traveling at a speed of 200 to 400 miles per hour, the abrasive strikes the surface, breaking and loosening the rust or scale, which falls to the ground.



The cleaning principle is the same in wheel blasting. Here, the spinning of large paddle wheels creates the force to throw the abrasive at the surface breaking off the rust and mill scale.



WHAT ARE THE ADVANTAGES OF BLASTING?

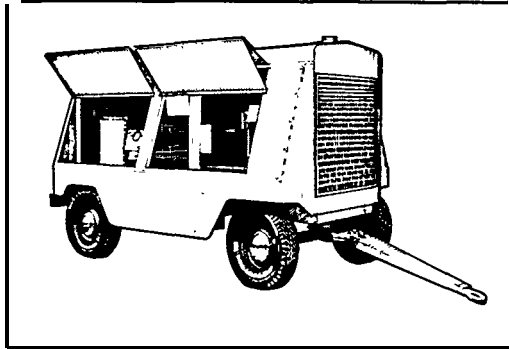
Blasting is the only method of surface preparation which can completely remove intact mill scale. It also provides the anchor pattern required for good paint adhesion.

Blasting is ideal for:

- high production work
- rapidly cleaning large areas
- removing tight mill scale and foreign matter
- creating a controlled anchor pattern
- profitability

## HOW IMPORTANT IS THE AIR COMPRESSOR?

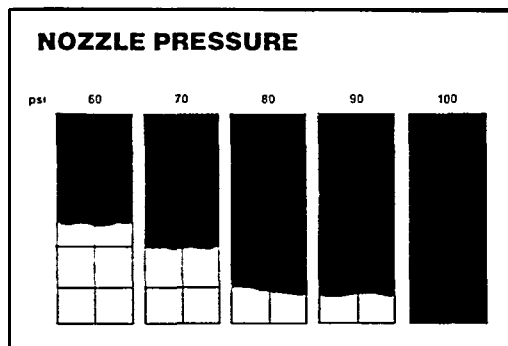
The compressor is the source of energy for the blasting job. The constant supply of a high volume and high pressure air stream, hour after hour, is the most critical part of the blasting operation.



Work is done in direct proportion to the volume and pressure at the nozzle.

The larger the compressor, the larger the nozzle it can operate. The larger the nozzle (at the proper pressure) the faster the job can be completed. For example, blasting on steel plate at 90-100 psi and an air volume of 170-220 cfm is done with a 3/8" nozzle.

The importance of nozzle pressure is illustrated here. These panels were blasted with the same equipment, for the same amount of time. Proper nozzle pressure, 90-100 psi, resulted in a 50 percent increase in cleaning efficiency over work done at 60 psi.



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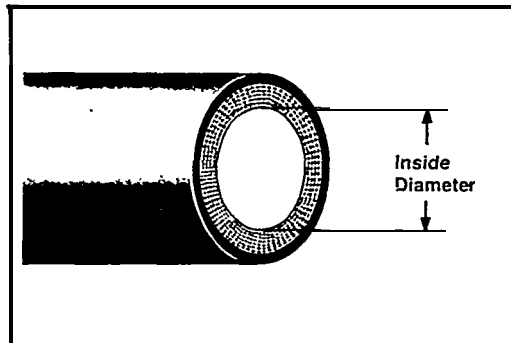
CHOOSE AIR HOSE TO  
MAXIMIZE EFFICIENCY

The air hose connects the compressor and the blast pot. For efficient blasting, the air hose should be:

• as large (ID) as practical: reduce friction and avoid air pressure loss (1 - 1 1/4 inch hose is usually recommended for shipyard work)

• as short as practical: reduce leakage with as few couplings as possible.

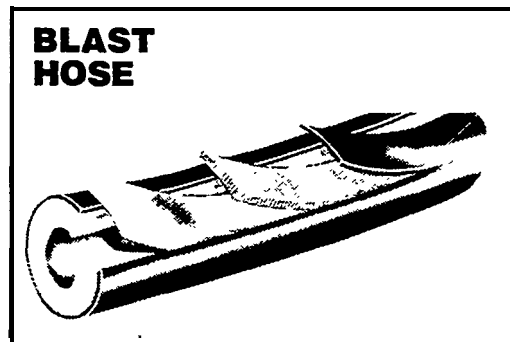
Hose sizes refers to the interior diameter, ID, of the hose. It is measured in inches. If the hose size is too small for the volume of air passing through it, friction will cause a loss of pressure and poor blasting efficiency. A 15% production loss can result from only a ten pound drop in pressure.



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REDUCING FRICTION IN THE  
BLAST HOSE WILL INCREASE  
PRODUCTIVITY

The blast hose connects the blast pot and the nozzle. It carries both air and abrasive. Sturdy 4-ply hose with 1 1/4 inch interior diameter (ID) is called for in shipyard work.



---

ARE THERE ANY PROBLEMS  
WITH BLASTING?

In spite of its efficiency and good results, some problems still occur, such as

- accumulation of used abrasives in tanks and bilges can be difficult to remove
- blowing dust and abrasive in the air can interfere with machinery, or the work of nearby craftsmen
- air borne dust can be harmful to the operator (a respirator must be worn while operating the equipment)
- abrasives are costly; recycling should be considered wherever possible

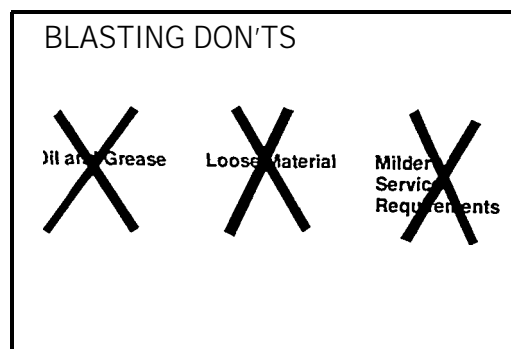
These problems can be reduced with correct use of the equipment and proper planning and scheduling.

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WHEN IS ABRASIVE BLASTING  
IMPRACTICAL?

There are some conditions in which blasting is NOT the most efficient method for surface preparation:

- . removal of grease and oil
- . removal of loose, coarse material
- . mild service requirements, allowing a **more** forgiving, oleoresinous type paint



## EQUIPMENT SET-UP FOR NOZZLE BLASTING EFFICIENCY

DESCRIBE THE FIVE BASIC PARTS OF A NOZZLE BLASTING SET-UP

An open or "nozzle" blasting rig has five basic parts:

1. the air compressor
2. the blasting machine
3. the blast hose
4. the air hose
5. the nozzle

WHAT IS THE FUNCTION OF EACH PART?

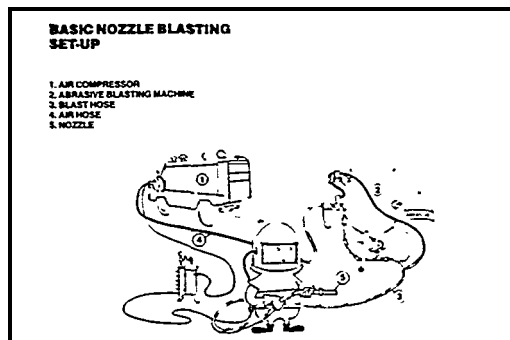
The air compressor provides the high pressure and volume of air needed to propel the abrasive through the nozzle onto the surface.

The blasting machine or "sand pot" is a container which holds the abrasives. A valve at the bottom measures and controls the amount of abrasive fed into the blast hose. This may be called a "carburetor valve."

The blast hose which carries the air and abrasive mix from the pot to the nozzle must be sturdy and flexible. It is treated to prevent electrical shock. Hose is sold in short sections which can easily be joined together to get the required length.

The air hose connects the compressor and the blast pot. This hose is not as rugged as the blast hose -- it can not be dragged on the ground nor carry abrasive materials.

Nozzles come in various shapes and sizes. Shipyard use recommends the venturi design and as long a nozzle (up to 8") as is practical for the-work area.



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A short length of lighter, more flexible, 2-ply hose with a 3/4 inch ID is sometimes joined in at the nozzle. These sections, called "whips," are easy to handle and are effective for work in areas with many angles, pipes, and stiffeners.

Avoid using whips in general shipyard work. They add length and the small interior diameter reduces pressure. Whips cancel the advantages gained by the large size blast hose.

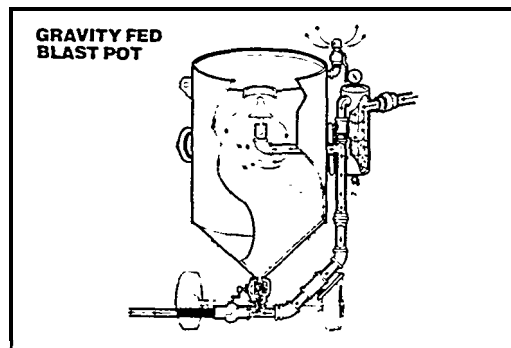
Rule of Thumb: Bigger and shorter are the key to air and blast hose efficiency. If a choice must be made between having a short air hose or a short blast hose, choose the short blast hose.

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#### CHOOSE THE RIGHT BLAST POT FOR THE JOB

A typical gravity-fed blast pot is pictured here.

For efficient operation, be sure you know the essential features:



- air hose
- moisture separator
- exhaust valve
- filling head
- metering valve
- hose/tank coupling

---

Efficient blasting depends upon:

- the right size pot for the job
- very few refill stops
- the release of an even flow of abrasive with the air stream

Proper abrasive flow is controlled by the metering valve. Some pots have an automatic valve which adjusts the flow rate as the air pressure changes.

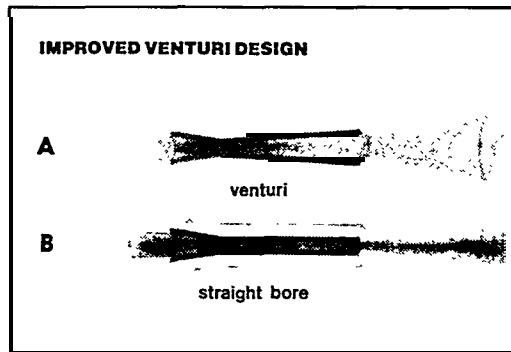
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HOW DOES NOZZLE SIZE AFFECT  
WORK EFFICIENCY?

The nozzle is a major tool in the blasting operation. Surface cleaning is done in direct proportion to the volume of air pushed through the nozzle at high pressure. **For example:** If 100 square feet per hour can be obtained with a 1/4" nozzle, 400 square feet per hour can be obtained with 1/2" nozzle. However, a nozzle can be too large for the air volume: Air will escape causing the pressure and production to drop.

Nozzles come in an assortment of lengths, sizes of opening, and lining materials. Because of the heavy demands of shipyard work, it is recommended that nozzles have the following characteristics:

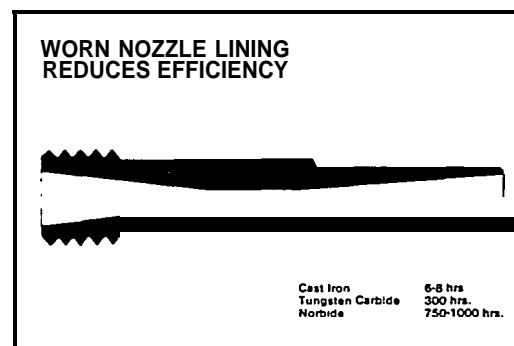
- venturi design
- long nozzle length
- Tungsten Carbide or Norbide lining
- large orifice size



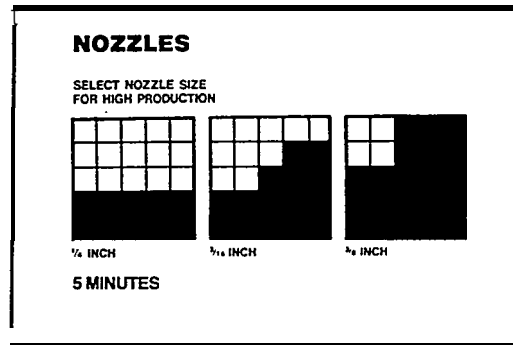
Venturi design. This refers to the tapered shape of the lining of a venturi nozzle. It has the advantage of increasing abrasive speed to 450 miles per hour and creating a larger, more even blast pattern. Production cleaning rates can be increased by as much as 30-50 percent by this feature.

Long nozzle length. Hard to clean surfaces require as large a nozzle as practical for the work area. Long nozzles, from 5 to 8 inches, will more easily remove tightly adhered deposits and mill scale. They also produce faster cleaning rates. Shorter nozzles, 3 inches or less, may have to be used behind beams or in other small or inaccessible areas.

Tungsten Carbide or Norbide lining. As the abrasive material flows past the nozzle opening, the lining wears away. The size of the opening, called the orifice, enlarges and cleaning effectiveness is reduced. Nozzle liners should be replaced when wear increases the opening 50 percent over its original diameter size. Tungsten Carbide and Norbide liners, when properly handled, have a service life of 300 hours and 750-1000 hours respectively.



Large orifice size. The available volume of air determines the orifice size. Choose the largest possible size that can be used on that job. Generally, a 1/2" nozzle will **clean** four times as much area in **one** hour as a 1/4" nozzle, with the proper air supply.



Nozzle Size as a Function of Volume of Air Flow and Air Pressure

Nozzle Size (inches)	Nozzle Pressure	
	90 psi	100 psi
1/8	18.5 cfm	20.3 cfm
3/16	41.0 cfm	45.0 cfm
1/4	74.0 cfm	81.0 cfm
5/16	126.0 cfm	137.0 cfm
3/8	173.0 cfm	196.0 cfm
7/16	240.0 cfm	254.0 cfm
1/2	309.0 cfm	338.0 cfm

#### TAKING CARE OF THE NOZZLE

At over \$100 per nozzle, proper care of the nozzle is important. Careless handling can damage this apparently sturdy tool.

- Never use the nozzle as a hammer. Sharp blows can crack the lining.
- Avoid dropping the nozzle. Damage to the orifice will distort the blast pattern.
- **Take care with insertion.** Proper threading will increase nozzle work life.
- **Avoid clogging.**

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TIPS FOR MAINTAINING  
BLASTING EFFICIENCY

- Place the compressor near the blasting job, as near as possible to the blast pot. Position it so that wind will blow blasting dust away from the compressor, assuring clean air intake.
- Run large air hose from the compressor to the blast pot. Large hose reduces friction in the line.
- Care for the equipment. Allow the compressor to warm up for 10-15 minutes before starting to blast. Set it at 120 pounds. DO NOT exceed 125 pounds. DO NOT overload.
- Keep the compressor clean. Fans, radiators and filters should not be clogged with dirt or they will overheat and overload.
- Check the compressor output every 6 months. An "orifice gage" is available for this purpose.
- Use external couplings when attaching hoses.
- Keep hoses as short as possible to minimize pressure loss.
- **Make 1 1/4 inch ID air hose standard practice.** Use a 3/4 inch ID whip **only in areas with many** angles or stiffeners where greater flexibility is a must.
- Avoid small sandblast hose.

Rule of Thumb: The ID (interior diameter) of the airblast hose should be three to four times the orifice size of the nozzle.

- Run hose in a straight line. Avoid 90 degree bends. If the hose must curve around an object, use a long curve. Consider safety as well as productivity. Sharp curves create rapid wear and could cause a blow out.
- Check for nozzle orifice wear.

## EFFICIENT AND SAFE PRACTICES FOR SURFACE PREPARATION

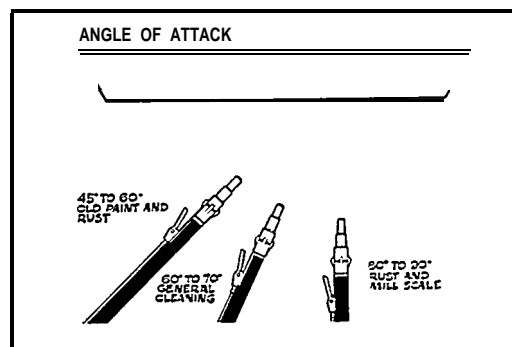
## GOOD BLASTING TECHNIQUE

For effective nozzle operation, the blaster must determine and maintain the

- proper angle of attack, and
- proper distance between the nozzle and the surface.

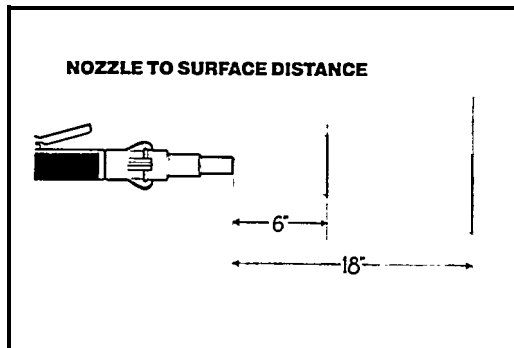
Experience is the best teacher. Experimentation with different angles and distances when starting a new job will determine what is more effective for that surface condition. Once the most efficient angle and distance are determined, the blaster should maintain them with each pass during the entire operation.

Angle of attack. The angle of the nozzle to the surface ranges from 45 to 90 degrees.

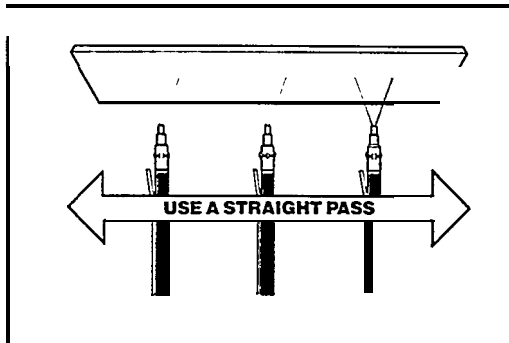


- To remove rust and mill scale: 80° to 90°. This angle is preferred for dislodging contaminants from pitted surfaces. A slight downward angle will direct the dust away from you and will make it easier to see.
- To peel off old paint and layers of rust, force the blast under the crust at 45° to 70° attack angle.

Nozzle to surface distance. The closer the nozzle to the surface, the smaller the blast pattern (the area hit by abrasives). With a small pattern, the abrasives are concentrated in a smaller area, make impact at a greater speed, and have more force. On a **small area**, the operator can blast more crust for the energy spent, but will cover less area in a given time. A distance of only 6 inches may be required to remove tight scale. To blast old paint, an 18 inch nozzle to surface distance is usually effective.

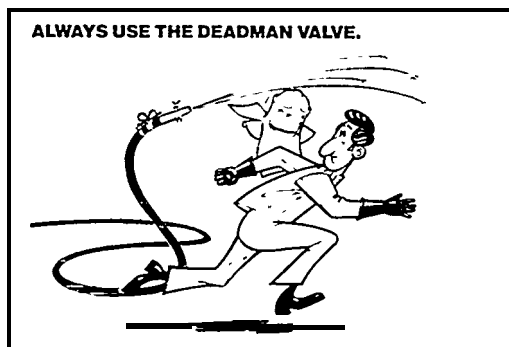


Each pass should be straight and at the same distance to produce work of uniform quality. There should be no arcing or varying the distance from the surface.



WHAT HAPPENS IF THE BLASTER MUST SUDDENLY STOP WORKING OR LOSES CONTROL OF THE NOZZLE?

The deadman remote control valve, placed close to the nozzle is designed for the blaster's safety. Always use this valve. Do not tie it down or fix it in the "on" position. When the valve is released, it shuts down the entire blasting operation. This eliminates the need for a second person to watch the blast pot and stop the operation.



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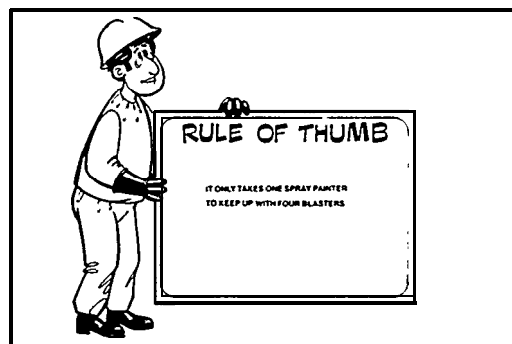
It increases the blaster's control at the nozzle. If it is improperly used, the blaster loses control, and could result in the loss of life or limb. Blasting equipment should be used with care and should also be shut down before clearing an obstruction in the hose or tank.

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HOW MUCH SURFACE ARE  
SHOULD BE BLASTED AT ONE  
TIME?

The size of the area to be blasted at one time should never be more than can be primed the same day.

Blast clean small sections and protect these with primer immediately. Do not blast a large steel section and leave it exposed. In humid areas, rust bloom or flash. rust can be seen on the exposed surface within hours. The work of removing this before painting is an unnecessary expense.



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HOW IS AIR PRESSURE  
MEASURED?

Use a hypodermic needle gauge to measure air pressure. Insert the needle in the hose as close to the nozzle as possible. This will indicate the pressure at the surface, where the work is being done.

Reading the gauge on the compressor or on the blast pot tells the pressure at those points only. If two or more lines are run off the same compressor, the pressure gauge might read 90-100 psi but that is NOT the pressure available at the work surface.

The needle gauge is easy to use

- a) Insert gauge into the blast hose as near the nozzle as possible.

- 
- b) The needle must point in the direction of the abrasive flow.
  - c) Measurement is made while the abrasive is flowing to give a true reading of the pressure of the air/abrasive mix which hits the surface.
  - d) Check the readings at the start of every shift.



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HOW IS THE QUALITY OF THE  
AIR SUPPLY MAINTAINED?

Air which carries dirt and oil defeats the purpose of blast cleaning. The air, as well as the abrasive, must be clean and oil-free. Water in the blast stream can cause spot rusting on steel.

Water and oil separators on the compressor and blast pot will solve the problem. They require regular attention.

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KEEP OIL AND MOISTURE AWAY  
FROM ABRASIVE MATERIAL

- Prevent contamination of the cleaned surface, and
- Prevent clogging of the blast nozzle.

Keep the abrasives clean and dry.

Abrasives carrying oil or water will stain and spot rust a steel surface. The cleanliness needed for paint to bond cannot be achieved. If sand is the abrasive, it may mix with water to clog the hose and nozzle.

To check the cleanliness of the abrasive, place a small amount of abrasive in a glass jar filled with water. Shake the jar. If an oil film appears on the surface of the water, the abrasive is not clean and should not be used.

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**HOW DO YOU JUDGE THE PROPER BALANCE OF ABRASIVE AND AIR?** An air stream from the nozzle should be a blue color. The abrasive will cause a slight change in color. This usually indicates a proper mix. Experience is the best teacher here.

Operators tend to use too much abrasive. This cuts down blasting speed, creates excess dust, and increases clean-up costs. Vary the mix by adjusting the metering valve.

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## SAFETY IS YOUR RESPONSIBILITY

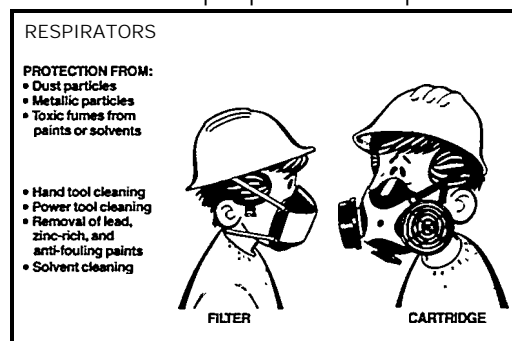
Major safety and health hazards faced by blasters include:

- respiratory problems
- toxic effects
- skin disease
- burns
- eye injury
- hearing loss
- fire and explosion
- equipment accidents

While these potential hazards exist on each, or site, there are also many safety measures which can be taken to avoid accidents and illnesses.

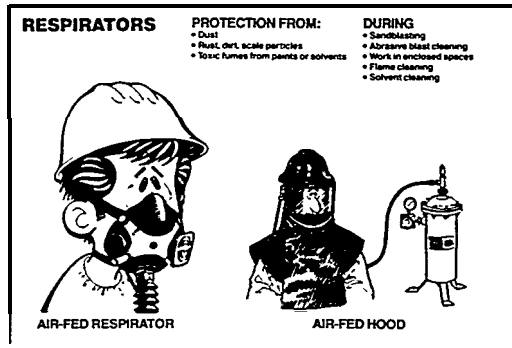
Understanding the function and capabilities of protective devices is your responsibility. Your health depends on using these devices correctly.

Respiratory problems. One of the most common hazards facing operators is respiratory disease due to dust or toxic fumes. Respirators provide good protection during all surface preparation operations.



During abrasive blast cleaning, air-fed respirators and hoods must be used especially if they are working in enclosed spaces where there is a great amount of dust.

Where sandblasting is still permitted, the dangers of silicosis make the use of an air-fed respirator a must. Removal of coatings containing asbestos fibers can also lead to bronchial problems, if the use of respirators is ignored.



Air-fed respirators are also recommended when solvent cleaning.

In order to be effective, all respirators must fit properly and be carefully maintained. Your employer should instruct you in how to wear and care for your respirator.

- Keep them in top working condition.
- Clean and check them after each use and replace filters on cartridges as often as necessary.
- Store them in a clean, dry container in a place that is free from exposure to solvents or other harsh cleaning compounds.

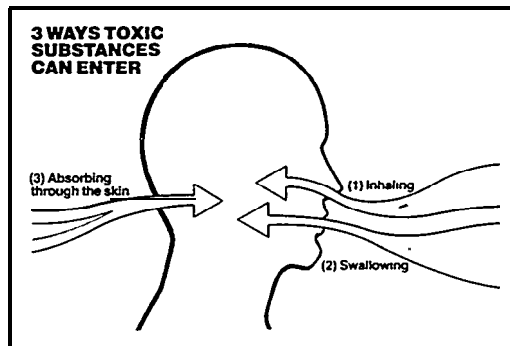
Adequate ventilation must also be provided during all surface preparation activities. Make sure your work area is properly ventilated to avoid respiratory damage.

Toxic effects. Toxic, or poisonous, substances and fumes can enter the body in several ways. They can be inhaled, swallowed, and absorbed through the skin.

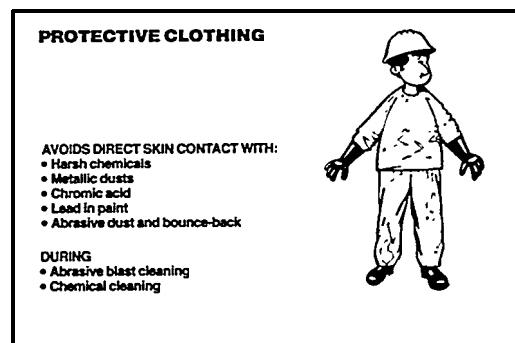
Damage to the nervous and digestive systems may not be noticed for many years. Long range effects may appear as lung diseases such as silicosis and certain forms of cancer.

Other toxic effects are immediate. Symptoms such as headaches, coughing, rashes and dizziness appear soon after contact with a poisonous substance.

Proper choice and consistent use of respirators and protective creams and clothing shield the body from these harmful substances. Adequate ventilation in the work area also reduces exposure to problem substances.

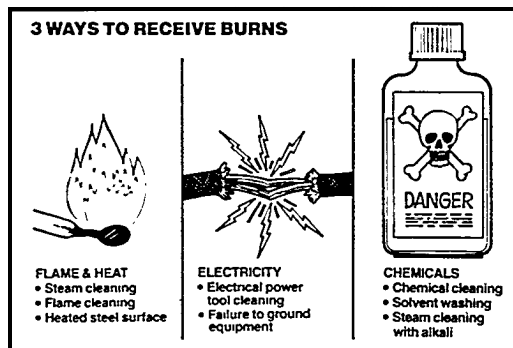


Skin disease. Skin irritation is a common problem among blasters. Skin rashes, also called dermatitis, can result from direct contact with an irritating chemical or certain metallic dusts. Lead poisoning can be caused by absorbing toxic dust through the skin. In chemical cleaning, burns and dermatitis can result from contact with chromates or chromic acid.



Skin irritations can be prevented by using protective skin creams and protective clothing, including heavy duty gloves. Abrasive blast cleaning also demands the use of protective clothing to protect all parts of the body from irritating dusts and abrasive bounce-back.

Burns. An operator can receive burns from heat, electricity, or from direct contact with chemicals. Flame cleaning requires particular care to avoid accidental burns from the flame or from the heated steel surface which reaches a temperature around 300 degrees F. The metal parts of a steam gun must be insulated to protect against heat burns.



Chemical burns are caused by direct skin contact with harsh, harmful chemicals, as in solvent cleaning. Rubber gloves should always be worn in this operation. Other protective clothing, such as coveralls and boots, can prevent solvent splashing from burning other areas of the body.

Steam cleaning may cause burns from the steam under very high pressure. When alkali is in the steam, any burns received will be even more severe. To guard against these hazards, wear a face shield, gloves and a protective rain suit.

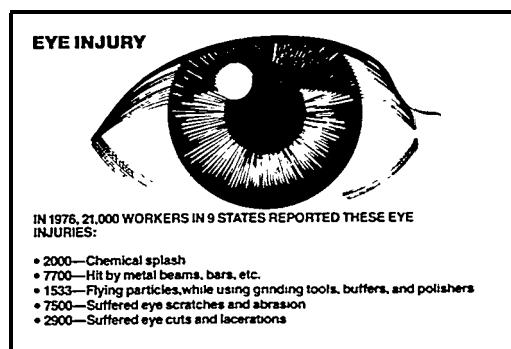
Ground all electrical power cleaning tools to prevent sparking and electrical burns. The equipment should be inspected for safe operating conditions. Tools with faulty plugs or broken wires may short-circuit causing electrical burns and/or fire.

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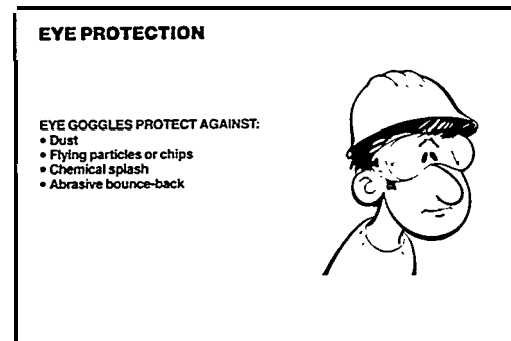
Eye injury. In 1976, 21,000 eye injury cases were reported by workers in nine states. Potential eye injuries include:

• impact (eyes struck by or against objects)

- chemical splash
- eye scratches and abrasions



Eye protection is an important precaution that must be taken during any surface preparation operation where there is a danger of flying particles or chips which can blind or cause other serious injuries. Wear safety goggles when using either hand or power tools. Safety goggles can also prevent dangerous solvents from splashing into eyes during chemical cleaning. Flame cleaning operations also require the use of safety goggles.

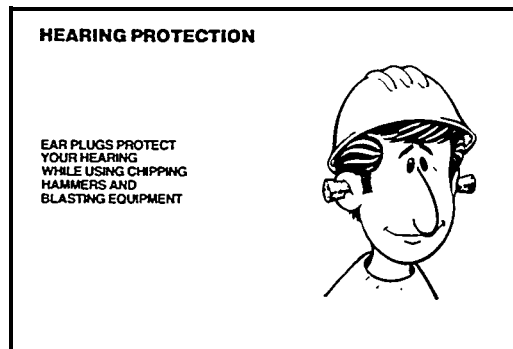


Hoods provide a greater degree of protection from dust and flying particles, shielding the eyes, face, neck and ears. In blasting, they protect your eyes and head from abrasive ricochet.

Hearing loss. Hearing loss can occur from exposure to high noise levels for long periods of time. In 1976, 328 workers experienced some loss of hearing in two states alone. Similar job-related cases were reported in the other 48 states.



The use of chipping hammers and blast equipment are two surface preparation operations which produce excessive noise. Wear ear plugs in all shipyard areas where operations with excessive and continuous noise levels are taking place.



Fire and explosion. The possibility of fire and explosions is a safety hazard faced by all surface preparation operators. Hand and power tools must be non-sparking and explosion-proof, especially in the presence of combustible vapors. Some abrasives can cause sparks when the particles strike the surface. If work is being done in a confined area, such as a tank, it must be proven gas-free. Sparks flying in an area containing flammable materials or combustible vapors present a potential explosion or fire hazard.

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In the use of chemical cleaning agents or volatile solvents, adequate ventilation is ALWAYS called for.

OSHA requirements state that "suitable fire extinguishing equipment shall be immediately available in the work area and shall be maintained (ready) for instant use."

Equipment accidents. Safe use of all surface preparation equipment will reduce the occurrence of accidents. All equipment should be inspected for good working condition.

In accordance with OSHA rules, faulty hand and power tools, such as cracked grinders and wheels or broken wires can cause serious injury to an operator. All power equipment should be held correctly and operated at the speed recommended by the manufacturer. Where necessary, tools should be effectively grounded.

The pressure of the tank used in abrasive blast cleaning must be carefully watched to make sure it does not exceed the maximum allowable pressure for the pot. "Sandpots" fall under the category of unfired pressure vessels and must meet certain standards.

During solvent cleaning, take care not to splash the chemicals. Machinery parts will be destroyed and scaffolding ropes could be weakened, resulting in serious accidents.

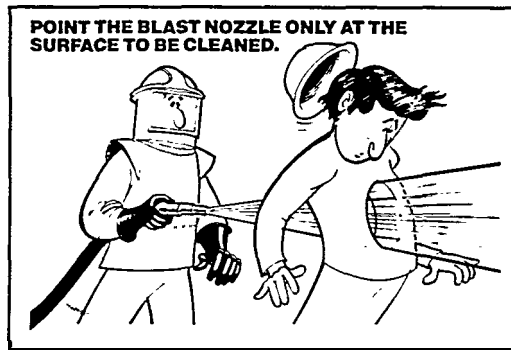
Electric shock can occur in certain situations. In blast cleaning, the nozzle should be grounded so it will not discharge high static electricity and shock the blaster. The shock itself is not lethal but falling off a scaffold may be.

In waterblasting, electric shock can be conducted through wet surfaces. All electrical operations should be shut down when waterblasting is in process.

Use all surface preparation equipment correctly and only for the intended purpose. "Horseplay" on the job should never take place. Pointing a blast nozzle or a flame torch at a person, even in fun, can be a deadly mistake. The powerful force of a blast stream is similar to a continuous-action shotgun which will cut ropes and other rigging, so it should never even come near scaffolding.

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Never point powerful equipment at anything other than the surface to be cleaned.



The use of safety belts and lines is an obvious precaution to take in any number of blasting situations above or below ground. Often their use is required by law. This is true when a blaster is working in a ship's hold or inside a chemical tank or grain elevator -- any situation where the blaster must be removed quickly in case of an emergency.

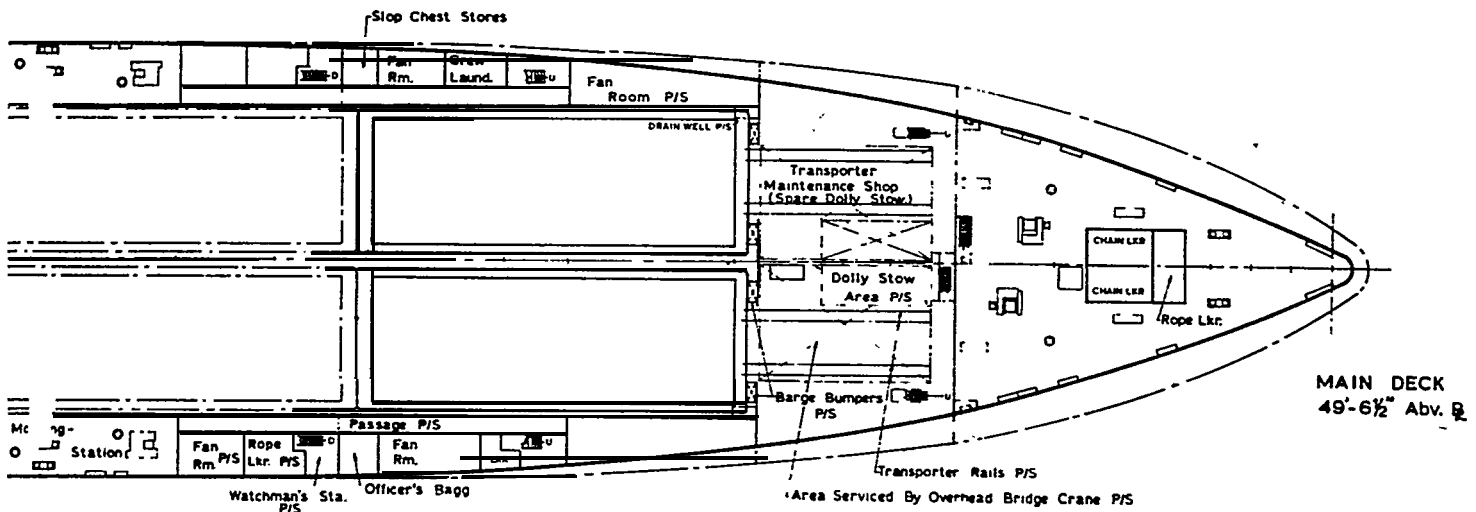
Where rigging of any kind -- scaffolding, swing stages, boatswain chairs, slings -- is used, safety belts and lines should have substantial guard rails. The force in a blasting pass tends to push the operator backward. Most blasters are aware of this force and stand in a braced position to lessen its impact on them. Safety measures include back rails, stabilizing lines, and sure footing.

Should an accident occur, you should know where emergency phone numbers are posted and where emergency equipment and supplies are located. OSHA requires that a first aid kit is provided for each vessel that is being worked on. At least one employee should be qualified to give first aid, if there is no separate first aid room or health attendant.

Blasters and other operators should be aware of the dangers which are possible in their jobs. However, safe use of equipment and other precautions will prevent accidents from occurring. Thorough safety training is essential for efficient and productive workers.

# PART C

## PAINT APPLICATION: TECHNIQUES AND PRACTICES.



### UNIT I GETTING READY TO PAINT

### UNIT II COMMON METHODS OF SHIPYARD PAINT APPLICATION

### UNIT III SET UP AND EFFICIENT OPERATION OF SPRAY EQUIPMENT

### UNIT IV GOOD SPRAYING PRACTICES

### UNIT V SAFETY AND HEALTH MEASURES IN PAINT SPRAY APPLICATION

GETTING READY TO PAINT

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## PROPER PAINT STORAGE

Paints are sensitive chemical compounds which must be stored and handled with care.

Proper paint storage can:

- eliminate fire hazards and the danger of explosion, and
- eliminate the waste of costly materials

Store paints in a separate room or building away from the work area.

Avoid:

- excess heat
- direct sunlight
- sparks or flame
- freezing temperatures

Good practices:

- rotate stock: a first in first out method is best
- keep the room well ventilated
- monitor the temperature
- store cans on pallets
- keep dry and clean: labels must stay attached so that the contents are easily identified
- keep sealed until ready to use: air and dirt shorten the shelf life -- use cans that have been opened for inspection or cans which have been partially used before the unopened cans

Avoid wasting paint through poor storage. At \$30 per gallon, the yard can't afford many discards.

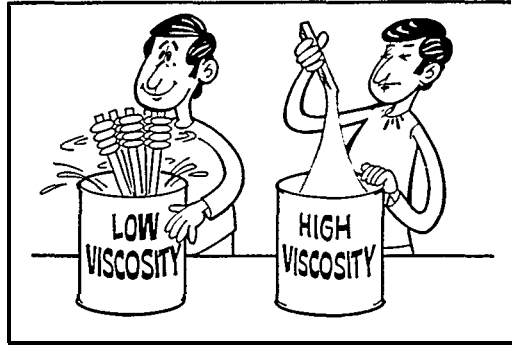
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VISCOSITY:  
WHAT IS IT?  
HOW IS IT CONTROLLED?

Paint consistency or "viscosity" is a measurement of how the material flows. A high viscosity paint is thicker and flows more slowly than a low viscosity paint.

The proper viscosity is essential for proper film build. It is also an important factor in:

- selecting the right equipment for spray application,
- obtaining good spray atomization, and
- obtaining satisfactory flow and leveling properties.



The three main factors which affect paint viscosity are:

1. the amount of solvent
2. the temperature of the paint
3. paint mixing

Solvent. Solvents are added by the manufacturer to dissolve the solids and create a liquid which can be brushed, rolled, or sprayed. The solvent's purpose is to provide "flow". It all evaporates and does not contribute to the properties of the dry paint film left on the surface.

Temperature. Temperature variations may cause great changes in viscosity. For paints that have been stored in cold temperatures, warming is recommended to restore the original viscosity.

Two-package paints are particularly sensitive to temperature. High temperatures can shorten the pot life giving the operator less time to apply the batch. Pay attention to temperature. It may be preferable to mix smaller batches rather than run the risk of the paint hardening in the lines and guns.

Mixing. During storage, the paint pigments tend to settle at the bottom of the can. Mixing the paint thoroughly spreads out the settled pigments to give the paint the smooth, even consistency necessary for proper application.

Adding Thinner. Nowadays, paints are manufactured ready for spray application without the need for additional solvent, or "thinner", to increase the flow properties.

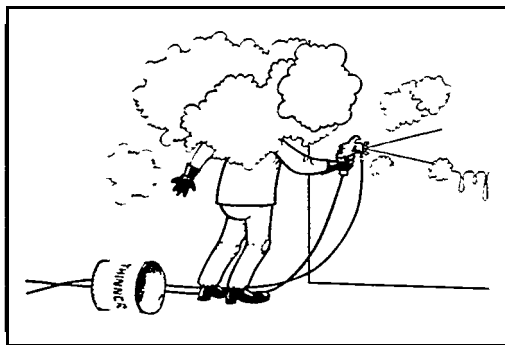
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Use thinner only if the manufacturer's data sheet specifies this step.

Following the instructions is absolutely necessary for adding the correct amount and type of thinner. If the wrong thinner is used, it may cause the paint to curdle or become lumpy. Once the quality of the paint is damaged, its original condition cannot be restored.

If too much thinner is used the film build will be too low. Over-thinning will:

- reduce hiding power
- provide inadequate corrosion protection
- cause runs and sags
- require repainting: extra work and extra costs
- create excessive spray fog, endangering the painter's health



Some new exotic paints reach the proper viscosity by shaking or stirring. They would be destroyed by the addition of thinner. When the lid is removed, these paints appear gel-like. A stick plunged into the center of the material would leave a hole when removed. However, with proper stirring the material becomes less thick (less viscose) and flows easily.

These paints are "thixotropic" or "false bodied". Follow the manufacturer's instructions for stirring. Apply when the consistency is similar to heavy molasses. DO NOT ADD THINNER.

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#### WHY IS PAINT MIXING CRITICAL?

Paint mixing is critical to ensure that the protective qualities of the paint are distributed throughout the coating film. Failure to mix in all of the solids upsets the chemical balance. For example, leaving zinc dust at

the bottom of the can means less galvanic protection for the ship. The surface may look well covered but it won't be well protected.

Proper mixing is also important to remove lumps which may clog the spray equipment.

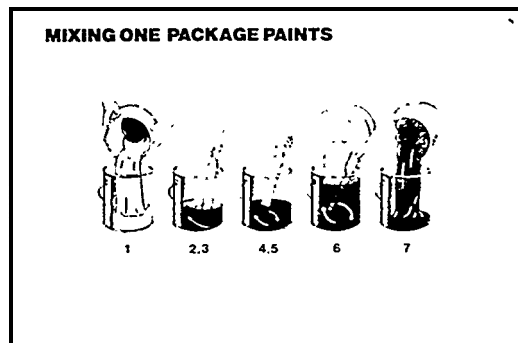
For paints with very heavy pigments, such as inorganic zinc and anti-foulants, constant agitation is required to keep the pigments from falling to the bottom of the can after the paint is thoroughly mixed.

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#### TIPS FOR MIXING ONE-PACKAGE PAINTS

Paint can be mixed manually or mechanically. For a small amount of paint (up to 5 gallons) manual mixing is satisfactory.

For paint that comes in one container, mixing involves these steps:



- Step 1. Pour off the thin portion of the paint into a clean container.
- Step 2. Stir the settled portion with a strong, clean paddle to break up the settled pigment.
- Step 3. Break the lumps by rubbing them against the inside of the can.
- Step 4. Use a figure 8 motion to mix thoroughly.
- Step 5. Follow with a lifting and beating motion.
- Step 6. Gradually return the thin, poured-off portion to the original container while continuing to stir.

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Step 7. When paint appears to be thoroughly mixed, it is "boxed". To box, pour the paint back and forth between the two containers until it reaches a smooth, even consistency.

Remember:

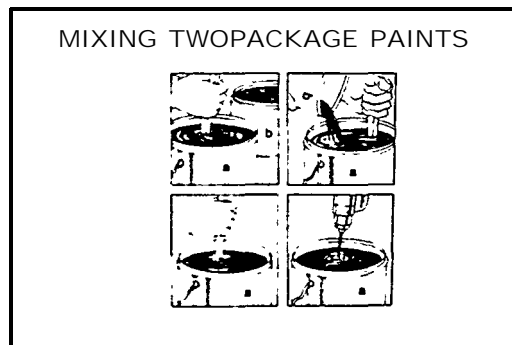
- Never use an air hose to mix paint. The air drives off the solvents causing a change in viscosity. Furthermore, the air cannot lift heavy pigments -- they remain at the bottom of the paint can.
- Mix only as much paint as necessary for a day's work.
- Do not leave paint in buckets or spray pots overnight. Gather the unused paint and put it into one covered container. Re-mix the paint thoroughly before using the next day.

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#### TIPS FOR MIXING TWO-PACKAGE PAINTS

Two-package paints, also known as catalyzed paints, cure by an internal chemical reaction. The chemicals must be kept separate until the paint is ready to be applied.

Catalyzed paints come in two separate packages. The larger package (A) is the base. The smaller package (B) contains the catalyst, or curing agent. Neither package may be used alone. The two packages must be combined before they can perform as a paint. If the catalyst (B) is not added to the base (A), the paint film will NEVER cure.



To mix two-package paints, follow these steps:

- Step 1. Stir package (A) to spread out the lumps of pigment that have settled. Use a clean paddle. Five minutes is usually adequate.

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Step 2. While continuing to stir, slowly add all of package (B).

Step 3. Agitate the two combined parts until they are a smooth, even consistency. Use either a manual or motorized agitator.

As soon as the two packages have been combined, the chemical reaction which leads to curing begins. The paint must stand for approximately 30 minutes before it is "set" and is ready to apply. This setting up, or "induction" time is a critical part of mixing two-package paints.

Once the two parts of a catalyzed paint are combined, the chemical reaction which leads to curing cannot be stopped. If paint is allowed to stand beyond its pot life, it will harden into a solid mass in the spray pot, lines, and guns.

Don't waste paint:

- Mix only enough for prompt use. In typical production spraying, 5 gallons will be sprayed in an hour. Mix smaller batches just before lunch or at the end of a shift.



- Don't leave paint in the lines and gun during lunch or a work stoppage. The hot sun will accelerate the curing time and shorten the pot life. Hours will be wasted cleaning or replacing the equipment.

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HOW DO YOU KNOW WHEN  
PAINT IS MIXED  
THOROUGHLY?

Take a sample of paint from the bottom of the container and compare it with a sample taken from the top. If the paint is not mixed thoroughly enough, the paint from the bottom will be thicker due to a higher pigment

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concentration. When the paint appears to be consistent throughout, it is properly mixed.

With all paints, straining should follow mixing to catch any remaining lumps.

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HOW DOES TEMPERATURE AFFECT PAINT APPLICATION? Temperatures of air, surface, or paint material that are too high cut down the pot life of the paint. Temperatures that are too low make the curing time longer.

Most **paints should be applied at air temperatures between 50-90 degrees F.** Using conventional application methods, the best temperature range is 70-90 degrees F. The temperature of the material should be at least as high as the surface to be coated. Follow manufacturer's instructions carefully.

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WHY DOES THE DEW POINT DETERMINE WHEN PAINTING CAN BEGIN?

Dew point is the temperature at which moisture condenses on a surface. Especially in the morning, during changing weather conditions, and during seasonal changes, condensation is common. This produces a thin film of moisture on the steel which may be invisible to the naked eye.

To avoid painting over moisture and causing drastic failures, the dew point should be measured. Painting should not begin until the surface temperature of the steel is five degrees above the dew point.

This five degree rule is a common, good practice to allow for errors in measurement and for temperature fluctuations.

COMMON METHODS OF SHIPYARD PAINT APPLICATION

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## WHAT ARE COMMON METHODS OF PAINT?

- Brushing
- Rolling
- Spraying

Brushing works the paint into all the pores and dents of the surface. Because it makes very close contact with the metal surface, brushing is a good method to use for applying the first coat of paint, called the "primer". Brush application is primarily used for touch-up jobs and in small areas, not for painting large areas.

Rolling can be used on large areas, such as decks and in interior areas where over-spray presents a cleaning problem. Never use a roller to apply the primer; the paint will not penetrate the surface well and will be applied over pores and dents. Rollers are used with good results after the primer has been applied.

Spraying is widely used in shipyards for high production. It is a mechanical method of applying paint in which the paint fluid is "atomized," or broken into a fine spray of small particles.

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TIPS FOR PROPER PAINT BRUSH USE

The brush is an important tool in the painting trade. Select good quality natural bristles or synthetic filaments which will not be destroyed by "hot" solvents.

1. Shake loose any unattached bristles by spinning the brush between your palms.
2. Snap off any stray bristles. A putty knife will help here.
3. Dip the brush into the paint to cover 1/3 of the length of the bristles. Do not cover the entire bristle length. The paint will fill the heel of the brush and run down the handle and operator's arm.
4. Remove excess paint by slapping the brush on the side of the can.
5. Paint with the tips of the bristles. Use a light touch. Don't press down hard on the bristles.
6. Always work from the dry to the wet surface. Do not pull the paint brush through wet paint to the unpainted surface.

- 
7. Avoid brushing paint out too thin, leaving unprotected **areas.**
  8. Always apply the second coat of paint at right angles to the first.
  9. Wash, shape, and dry the brush after each use for long life.

Proper use of a paint brush will result in good coverage and a smooth finish with a minimum of effort.

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#### TIPS FOR PROPER ROLLER USE

For painting on steel, select a roller with a proper nap length. Be certain that the roller core will resist strong solvents and the fiber will not loosen and stick to the coated surface. A phenolic core is often recommended.

1. For thick-bodied coatings, dip the roller directly into the paint container. For thin-bodied coatings, dip the roller into a roller tray.
2. To apply the paint evenly, the roller must be properly loaded. Skidding or tracking will occur if the roller is too dry or is loaded with too much paint. Do not roll the paint out too thin -- the roller should have enough material to provide a sufficient film thickness.
3. Do not apply heavy pressure -- it is not necessary for good film build and makes the work more difficult.
4. Apply the second coat at right angles to the first.

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#### WHAT IS THE DIFFERENCE BETWEEN CONVENTIONAL AND AIRLESS SPRAY?

There are two spray methods: conventional and airless. They differ mainly in the way the paint fluid is atomized. In a conventional spray gun, jets of compressed air are shot into the paint stream at the nozzle. The paint is broken up and carried to the surface on this air stream. In the airless method, the paint is forced through a very small opening at the nozzle under very high pressure. It is broken into tiny particles as it is released from the nozzle.

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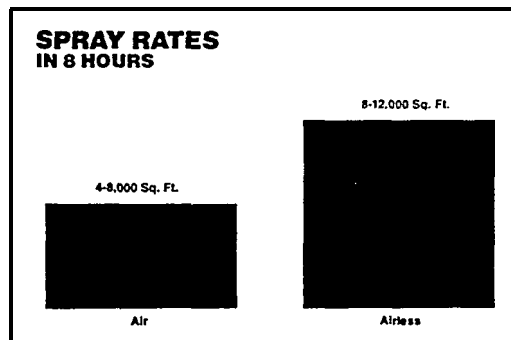
### Conventional :



- With the conventional spray method paint is carried to the surface on a current of air. A high amount of paint loss, due to bounce-back or overspray, can result.
- Conventional spraying provides a finer degree of atomization and a higher quality surface finish than the airless.
- Many painters feel that control is better with conventional guns and prefer them for detail work, pipe work, etc.

### Airless:

Airless spraying provides the fastest application speed and is therefore an excellent method for painting large areas. In an 8 hour period, a painter using airless spray equipment can apply paint to almost twice the area that he can with conventional spray equipment.



- One airless coat of paint will often give greater film thickness than two air-sprayed coats.
- When the paint is forced out of the airless nozzle at high pressure, the only material that comes out is paint.

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Since no air mixes in with the paint fluid, there is very little danger of moisture or dirt ruining the paint finish.

- The high pressure also forces the paint into cavities and corners with little rebound from the surface.

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HOW DOES SPRAY PAINTING  
COMPARE TO OTHER METHODS  
OF PAINTING APPLICATION?

Both conventional and airless spray are faster than brush or roller application.

Ž The paint supply comes through the gun -- there is no need to dip a brush or roller into a paint container.

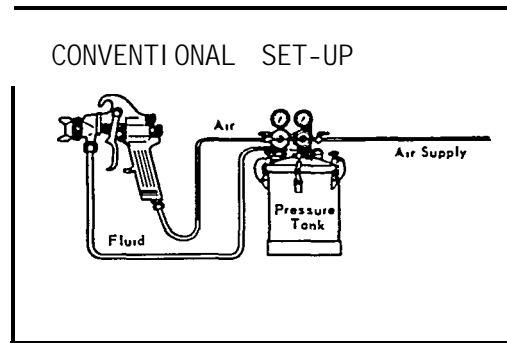
- The time it takes to paint a large area is greatly reduced. A painter using a brush can apply paint to 1,000 square feet in 8 hours. With airless spray equipment, he can cover the same area in at least 1/8 the time.
- Spray application provides a high, even film thickness and good appearance in one coat at an increased production rate.

## SET-UP AND EFFICIENT OPERATION OF SPRAY EQUIPMENT

WHAT ARE THE BASIC PARTS OF A CONVENTIONAL SPRAY SET-UP?

The basic parts of a conventional spray set-up are:

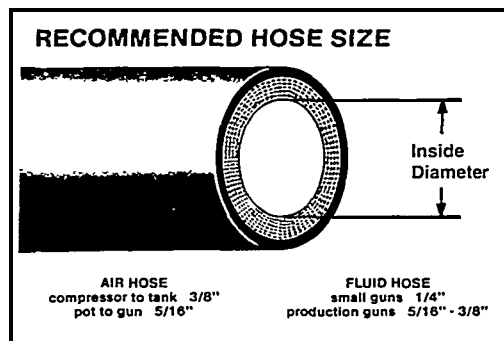
- air compressor
- paint tank
- hoses for air and fluid
- spray gun



The air compressor supplies the power for the conventional air spray system. Proper output is essential to properly atomize the paint.

The paint tank holds the material. The pressure feed paint tank helps to control the pressure at which the equipment is operated by providing a constant flow of material at a uniform pressure to the spray gun.

The air hose carries the compressed air and the fluid hose carries the paint material. Both hoses are identified by their "ID", interior diameter, size. The ID is important to know because it determines how much air and paint the hoses can deliver.

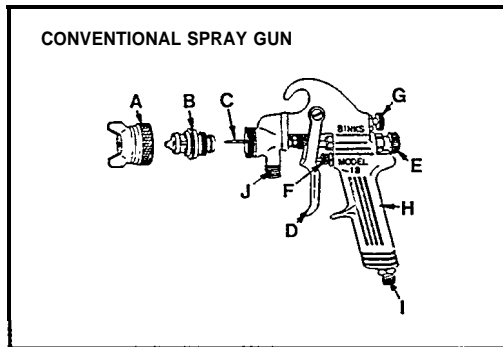


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An air hose which is too small for the job will restrict the volume of air causing the pressure to drop in the air line and starving the gun.

The fluid hose must be selected to resist the harshness of the solvents and paint chemicals that flow through it.

The spray gun allows the painter a great deal of control. There are ten basic parts to the gun and each one has a specific purpose:



- a. Air nozzle or cap: The air nozzle directs the compressed air into the stream of paint. The air atomizes the paint at this point and directs the flow of particles onto the surface.
- b. Fluid nozzle or tip: The fluid nozzle regulates the amount of paint released and directs the paint into the stream of compressed air.
- c. Fluid needle: The needle starts or shuts off the fluid flow through the fluid nozzle. Select the fluid nozzles and needles in pairs, as they must be the same size to operate correctly.
- d. Trigger: The trigger operates the air valve and the fluid needle.
- e. Fluid adjustment screw: The fluid adjustment screw controls the fluid needle to allow more or less paint to get to the fluid tip.
- f. Air valve: The air valve controls the rate of air flow through the gun to the nozzle.

- 
- g. Side port control: The side port control regulates the supply of air to the air nozzle and it determines the size and shape of the spray pattern.
  - h. Gun body and handle: The gun body is the part of the equipment the painter holds to operate the spray gun.
  - i. Air inlet: The air inlet is at the bottom of the handle and is connected to the air hose.
  - j. Fluid inlet: The fluid inlet is an opening below the fluid needle and is connected to the fluid hose.

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#### SETTING UP CONVENTIONAL SPRAY EQUIPMENT

With a pressure tank system, the setting up procedure is as follows:

1. Attach the air hose from the compressor tank, or control device such as an air transformer, to the air inlet on the pressure tank lid. Connect the atomizing air hose and paint hose to the spray gun. Tighten all connections with a hose wrench. Do not use pliers or pipe wrenches.
2. Open the relief valve on the tank. Keep valves to tank and hose closed.
3. Fill tank or removable tank liner with paint.
4. Fasten lid to tank. Tighten clamps.
5. Close relief valve.
6. Start the compressor.
7. Open the valve to the tank but not to the atomizing air hose.
8. Open the air spreader and fluid adjusting valves on the spray gun.

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At this point, you must decide what pressures to use for the job. Use the manufacturer's instructions as a guide and determine the pressure settings as follows:

1. Remove the air cap from the gun.
2. Trigger the gun and increase the fluid pressure until a stream of paint shoots out about three feet before it begins to fall into a pail on the floor. Release the trigger.
3. Replace the air cap and set the air pressure somewhat below the recommended setting. Test the spray pattern. Increase the air pressure by five pounds at a time until you obtain the best atomization.
4. Spray a small area of surface. If the paint seems too dry, reduce the air pressure or increase the paint tank pressure until the test spray pattern and finish is just right. Do whichever adjustment will come closest to the manufacturer's specifications.

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WHAT IS THE PROCEDURE FOR SHUTDOWN OF CONVENTIONAL EQUIPMENT?

Follow this checklist for the basic procedure, but always read the manufacturer's instructions for the actual equipment being used.

1. Close air inlet valve to the tank. Leave atomizing air to gun turned on.
2. Open relief valve on the pressure tank. This will repressurize the tank.
3. Open the tank lid carefully.
4. Loosen the air cap on the gun about a half turn. Hold a wadded cloth over the cap and trigger the gun. This will force any paint in the gun and hose back to the tank. CAUTION: This operation called "blow-back", can only be used with conventional air spray. It must never be used with the airless spray painting equipment.

- 
5. Remove paint from the tank. Clean the insert or interior of the tank by pouring a small amount of solvent into the container.
  6. Pour enough solvent into the tank to also wash the interior of the spray gun and hose.
  7. Trigger the gun and allow the solvent to run through the gun until the solvent comes out free of paint particles. Repeat the blow-back procedures.

---

#### HOW TO CORRECT FAULTY AIR SPRAY PATTERNS

The ideal spray pattern with a conventional gun is a long oval with clear edges. Experience will help you observe the spray pattern to be able to adjust the gun and correct faulty shapes.

Following are some of the most common air spray pattern problems and how to correct them.

A. "Boomerang" pattern.

Cause: Dried paint in one of the side port holes of the air nozzle. At full pressure, the air and paint exit from the clean side port.

Remedy: Dissolve the dried paint with thinner. Do not use metal devices to probe into the air nozzle openings.

B. Larger at one end.

Cause: 1) Dried paint around the outside of the fluid tip, restricting the passage of atomizing air.

2) Loose air nozzle; also bent fluid nozzle or needle tip.

Remedy: 1) Remove air nozzle and wipe off the fluid tip with thinner.

2) Tighten the air nozzle and replace any bent parts.

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C. Hour glass pattern.

- Cause:
- 1) Air pressure is too high.
  - 2) Not enough paint; fluid pressure is too low.
  - 3) Too wide a pattern with thin paint.

- Remedy:
- 1) Reduce the air pressure.
  - 2) Increase fluid supply.
  - 3) Adjust pattern control knob.

D. Heavy middle.

- Cause:
- 1) Air pressure too low.
  - 2) Too much fluid fed to the gun.

- Remedy:
- 1) Increase air pressure.
  - 2) Decrease fluid pressure or use a smaller fluid nozzle orifice.

E. Fluid spitting; air entering fluid supply.

- Cause:
- 1) Dried or missing packing around the fluid needle valve.
  - 2) Dirty fluid nozzle seat.
  - 3) Loose fluid nozzle, packing nut, fluid hose.

- Remedy:
- 1) Clean packing with light machine oil.  
Replace if necessary.
  - 2) Clean fluid nozzle seat area with thinner.
  - 3) Tighten connections and fittings.

---

WHAT ARE THE BASIC PARTS  
OF AN AIRLESS SPRAY SYSTEM?

The three basic parts of airless spray equipment are:

- high pressure paint pump
- paint hose
- airless spray gun

The high pressure pump draws the paint from the container and forces it through the paint hose and spray gun.

The paint hose must be able to stand very high pressure as it carries the paint from the pump to the gun. Most painters will require only 1800 psi to 3500 psi, but most airless hoses can handle pressure of up to 5000 psi. The hoses range in size to accommodate paints which have different viscosities.

The spray gun is basically a fluid nozzle and a valve. It is a passageway for different types of paint and spray patterns. There is a spray tip filter which screens out large particles of paint that could clog the tip. Each spray tip is designed to give a specific spray pattern and flow. There is only one hose -- the high pressure paint hose -- connected to the gun.

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HOW IS THE AIRLESS  
EQUIPMENT SET-UP?

The basic procedure for airless equipment set-up is as follows. Read the manufacturer's instructions for specifics regarding the type of equipment in use.

1. Connect air supply hose between air inlet on the pump and the air supply.
2. Connect the high pressure fluid hose between filter manifold (or pump outlet) and the spray gun.
3. Make certain that the regulator adjustment is backed off, then open the main air supply valve to the regulator.
4. Immerse fluid pump or siphon hose in container or suitable solvent.

- 
5. Turn air regulator adjustment until pump begins to operate slowly.
  6. Direct spray gun into solvent container and pull trigger.
  7. Increase air regulator and run pump for approximately 30 seconds at a moderate speed. Back-off regulator until pump stops.
  8. Check all hose connections for leaks.
  9. Remove siphon hose or fluid pump from solvent.
  10. Open regulator and allow system to pump out solvent.
  11. Allow air to flow through system for about 30 seconds.
  12. Check agitator and other air operated accessories for proper functioning.
  13. Shut off air inlet.
  14. Strain paint and other similar fluids before filling reservoir.
  15. Fill the fluid reservoir.
  16. Immerse siphon hose or pump in fluid.
  17. Select proper tip.

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HOW IS AIRLESS  
EQUIPMENT SHUT DOWN?

After use, these procedures should be followed for shutting down the airless spray equipment.

1. Shut off air to pump by closing the air supply valve.
2. Decrease air pressure regulator.
3. Release fluid pressure by placing gun below material in the fluid reservoir and pulling trigger until fluid ceases to flow or by opening by-pass valve if so equipped.

- 
4. Remove pump or siphon hose from fluid container.
  5. Remove nozzle tip from gun and place in solvent.
  6. Insert pump foot valve or siphon hose in container of suitable solvent.
  7. Open air valve.
  8. Increase pressure regulator until fluid pours slowly from gun. Direct flow into fluid container.
  9. When solvent flows from gun, direct the stream into the solvent container.
  10. Allow the solvent to circulate several minutes, then change to clean solvent. Do not let dirty solvent circulate.
  11. Circulate once more, triggering the gun periodically to change the pressure in the pump. Continue until system is clean.
  12. Never back-flush an airless gun. It can be a deadly way to clean an airless spray gun.

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WHY IS SPRAY TIP SELECTION  
IMPORTANT IN THE AIRLESS  
METHOD?

There is only one way to control the spray pattern from an airless gun: choose the right tip.

Each airless spray tip has one spray pattern. The type of pattern used depends on the type of work being done. Wide spray patterns are used for high production work on large surfaces. Narrower patterns are for closer and finer spray painting work. The wider the angle of the opening, the larger the pattern, and the more spray coverage is possible.

Select the proper tip according to the fluid viscosity, the rate of application, and the spray pattern desired. Determine the largest pattern and the smallest orifice practical. Two tips can have the same orifice size and different spray angles -- they will spray the same amount of paint, but the width of the pattern will be different. Every time a different pattern is needed, the tip must be changed.

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DO FAULTY PATTERNS  
APPEAR WITH AN AIRLESS  
GUN?

Yes, a faulty spray pattern usually means that the tip, filter, or pressure must be adjusted. A good airless spray pattern is an oval with clear edges.

Here are some of the most common airless spray pattern problems. To correct these problems, you must have a good working knowledge of airless spray equipment.

A. Tails or hour glass shape.

Cause: Inadequate fluid delivery or improper fluid atomization.

Remedy: Increase fluid pressure; decrease fluid viscosity; choose larger tip orifice; clean the gun and filters; or reduce number of guns using one pump.

B. Heavy at one end, distorted.

Cause: Clogged or worn nozzle tip.

Remedy: Clean the nozzle tip; replace if necessary.

C. Rippling, uneven pattern.

Cause: Pulsating fluid delivery or suction leak.

Remedy: Increase supply to air motor; reduce number of guns using one pump; choose smaller tip orifice; clean tip screen and filter; or look for hose leak.

D. Round pattern.

Cause: Work nozzle tip or fluid too heavy for tip size.

Remedy: Replace worn tip; decrease fluid viscosity; increase pressure; or choose correct nozzle tip.

E. Fluid spitting.

Cause: Air entering system; dirty gun; or wrong cartridge and adjustment.

Remedy: Look for hose leak; clean the gun; or adjust cartridge and replace if necessary.

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## LEANING AND LUBRICATING A SPRAY GUN

Most spray painting problems a painter experiences are directly related to improper or inadequate cleaning of spray guns. Both conventional and airless spray guns should be thought of as precision tools and they should be cared for as such. They must be kept lubricated and clean.

Follow these rules for keeping an air spray gun in its best working order:

- Never soak the whole gun in solvent. Solvents remove lubricants and dry out the gun packings. Dirt can collect in the air passages and can later mix with the paint and be sprayed onto the surface.
- Lubricate the air spray gun every day with a drop of light machine oil to keep the parts moving easily. The points that need lubrication are the:
  - a. trigger pivot,
  - b. fluid packing nut,
  - c. air valve packing,
  - d. fluid needle spring, and
  - e. side port and control knobs.
- Wash the gun body with a rag dipped in solvent. To clean other exterior surfaces, only the front end of the gun is put into solvent. A non-wire brush should be used to remove any paint that has dried on the surface.
- To unclog the air nozzle, remove and wash it separately in clean solvent. A pipe cleaner, a broom bristle, or a match can be used to clean the holes. Wire or other sharp instruments may cause permanent damage to the nozzle and should never be used.
- Never use oils or lubricants containing silicones.

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With an airless spray gun, the most common operating problem is due to the tip getting clogged. All airless equipment should be flushed with solvent after each use. The fluid hose should be cleaned as well. The most common cause of clogging is dried paint flaking off the inner walls of a used paint hose. To clean the airless tip:

Ž Relieve fluid pressure

Ž Rotate trigger release to safe position

- Remove cap, nozzle tip and gasket

Ž Flush nozzle tip with solvent

- Blow air through tip and look for blockage

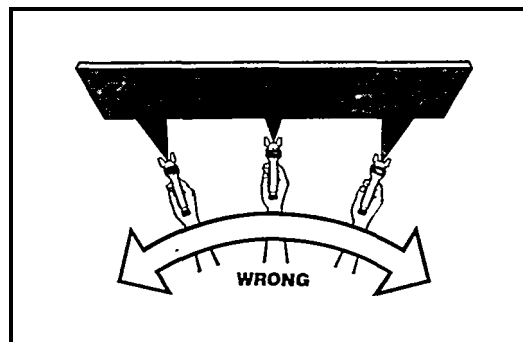
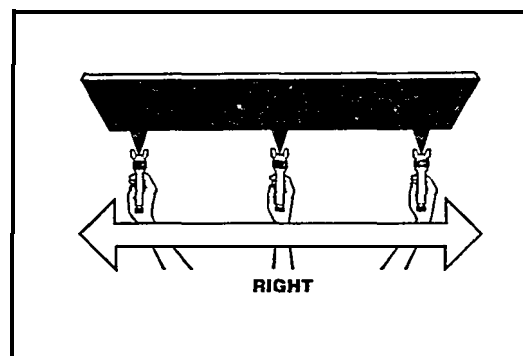
## GOOD SPRAYING PRACTICES

**WHAT IS A GOOD TECHNIQUE  
IN USING A SPRAY GUN?**

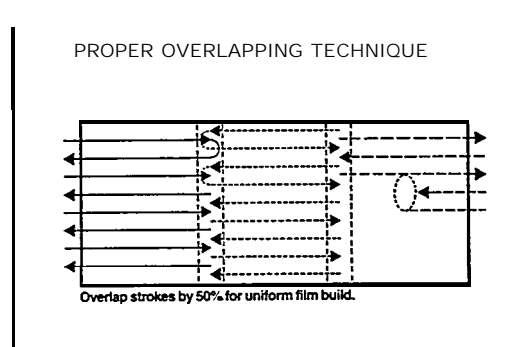
Proper stroking technique is essential to good spray painting. Poor techniques can use excessive material and the personal energy of the painter. Basically, the same techniques are used with conventional and airless spraying. The following rules are basics and should be used in both methods of spray painting.

Stroking

- While holding the spray gun at the proper angle, move the arm and shoulder as well as the wrist to prevent "arcing" which gives an uneven coat. The arm **MUST** remain at right angles to the surface.



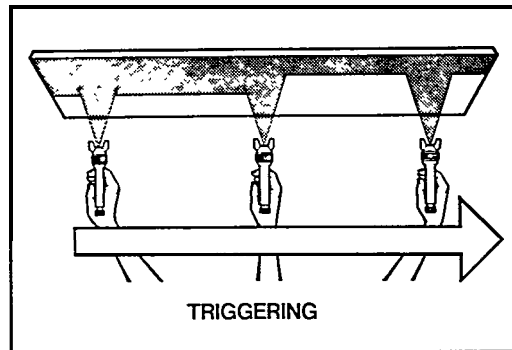
- Each stroke should overlap the previous stroke by 50 percent. If uniform overlapping is maintained, the film thickness will be uniform.



### Triggering

The spray gun should be triggered at the beginning and end of each stroke. The gun should be in motion before triggering and before releasing at the end of a stroke. This method helps to give accurate control of the spray

**gun and the materials:**



Triggering also functions to:

- keep the fluid nozzle or airless tip clean;
- reduce paint loss;
- prevent heavy build-up of paint on corners and edges;
- eliminate the build-up of fluid on the nozzle and tip which could cause the gun to give off a heavy deposit on the work; and
- prevent runs and sags at the beginning and end of each stroke.

---

## Speed

Spraying should always be done at a consistent rate of speed. The proper speed deposits a full, wet coat with each stroke. A slow stroke deposits a thick film and a faster stroke applies a thinner paint film. If quick stroking is needed to avoid flooding, then the fluid nozzle is too large or the fluid pressure is too high. If slow stroking is necessary to get a wet coat, increase the fluid pressure or the size of the fluid nozzle. Speed and rhythm are developed with experience.

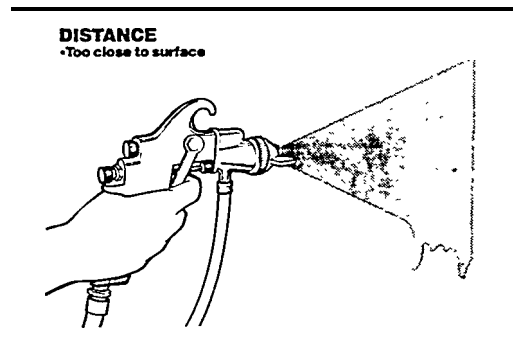
Ž Too slow = heavy, wet film build

Ž Too fast = light, dry film build

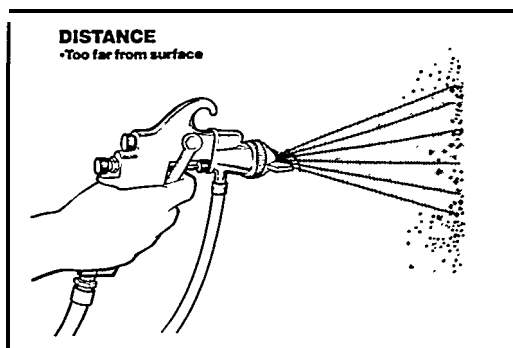
## Distance

The material and atomization pressure determine the proper distance from the surface. It may vary from 6 to 12 inches for conventional spraying and 12 to 15 inches for airless, which gives a wetter spray. The paint should always go on evenly and wet.

- If the spray gun is held too close to the surface, the paint will go on too heavy and tend to sag.



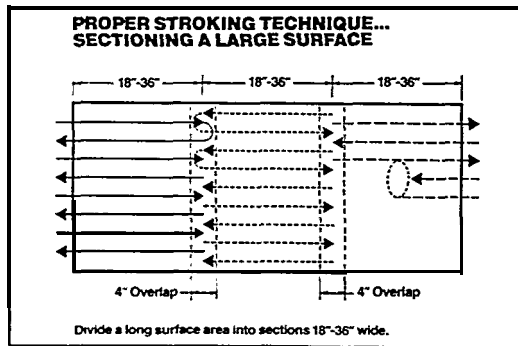
- If the gun is too far away from the surface, there is excessive spray dust which gives a sandy finish.



WHAT IS THE BEST WAY  
TO SPRAY A LONG  
SURFACE AREA?

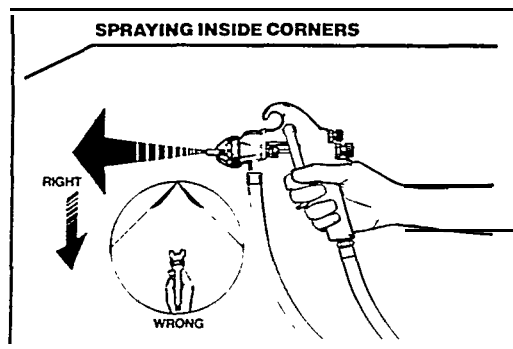
The ideal stroke length is from 18 to 36 inches.

When a surface area is too long to be coated with one stroke, it is divided into separate sections of convenient length. The basic triggering and horizontal stroking technique is used on each section. Each area slightly overlaps the previous one to give an even and continuous film.



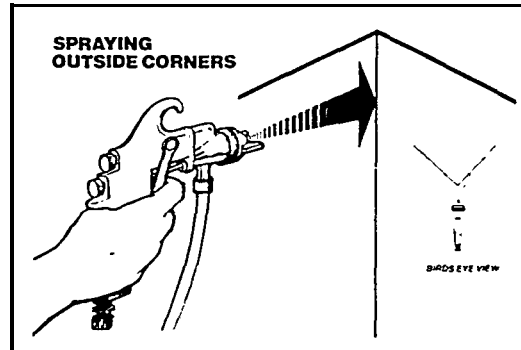
ARE THERE SPECIAL  
TECHNIQUES FOR CORNERS?

To get an even film build, each side of an inside corner should be sprayed separately. If the spray gun is aimed directly into the corner, the coating will not be uniform -- it will go on too thin in the corner and too heavy at the sides. For an even coating, a vertical stroke is used at one side, followed by short horizontal strokes applied in the direction away from the corner.



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When spraying an outside corner, the gun is aimed directly at the corner. One stroke coats the corner and the adjoining sides at the same time. Each side is then sprayed separately.

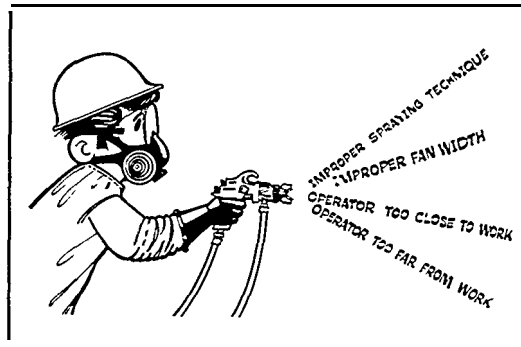


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#### PROPER TECHNIQUE REDUCES FILM DEFECTS

Many film defects are caused by improper spray application technique. The operator can control the appearance of these defects at the time of application.

The following are some common problems which the operator can control by adjusting technique.



#### Improper Spraying Technique.

(stiff wrist, swinging arm; tilting gun)

- spray pattern on surface will vary from narrow to wide (like an hour glass) with each spray stroke
- possible variation of sheen due to overspray on work just completed
- uneven film thickness affecting the film durability

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### Improper Fan Width.

Ž inadequate film build in the angle vertex or fillet of "I" and "H" beams when a painter uses a wide fan and sprays at a 45° angle from the flange into the corner. An excessive film build in the web and flange may also occur

Ž inadequate film build on bar joists when too wide fan is used

### Spray Operator Too Close to His Work.

Ž excessive film build

Ž runs, curtains, sags

Ž poor film adhesion due to improper drying and curing

- high film build; wrinkles while drying and may hold contaminants
- excessive paint used

Ž orange peel pattern and blow holes

### Spray Operator Too Far Back from His Work.

- film build too thin

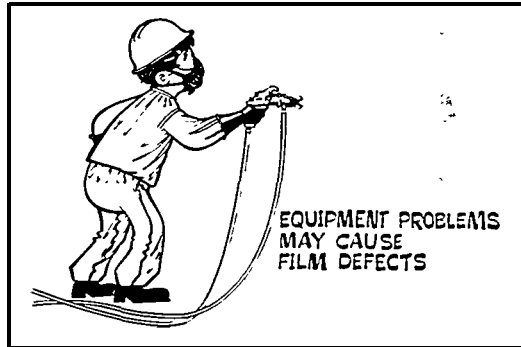
Ž uneven film build

- dry spray: the film is permeable
- uneven angular sheen due to overspray on finished work
- overspray deposits on unprotected substrate
- excessive paint used

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## EQUIPMENT PROBLEMS MAY CAUSE FILM DEFECTS

The operator should be very familiar with his equipment so he can avoid film defects caused by difficulties with the equipment. Following are some common equipment difficulties and the problems that may result.



Worn or damaged spray tips. Damaged or worn tips are the most common problem in airless spraying. They can be detected by a lopsided or distorted spray pattern. Strings or fingers of atomized paint particles may also be observed as well as:

- . uneven film thickness;
- . runs and sags in paint film; and
- . permeable film.

Atomization pressure too high. Excessive pressure may result in sags, runs, wrinkles, alligatoring and other defects associated with too thick a coating. These are particularly noticeable around irregular shapes that require more than one spray pass.

Partially clogged high pressure fluid strainers. A large drop in pressure at the gun when the trigger is pulled will be observed. This results in poor atomization.

Spray equipment undersized for the job.

- Lower production rate could promote the appearance of laps when using fast drying coatings.
- If the spray tip is too large for the machine, then a coarse, inadequately atomized coating will be applied which will leave a permeable film.
- The spray operator may spray to cover rather than spray to a specified film thickness to reduce the application time. The end result is a film that is too thin.

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Paint hoses too long or too small in diameter.

Ž A coarse inadequately atomized coating will leave a pebbly appearance.

Ž The film will have thin spots affecting durability.

Air supply hoses too small or too long.

- The paint pump cannot maintain constant pressure.

Ž The spray pattern will show inadequate atomization in the form of a coarse and pebbly texture and strings and fingers coming from the spray gun.

Ž Pulsation of the spray pattern, changing size of the atomized paint particles, and fluctuation of the spray fan width delivers an uneven film thickness and may affect film durability.

## SAFETY AND HEALTH MEASURES IN PAINT APPLICATION

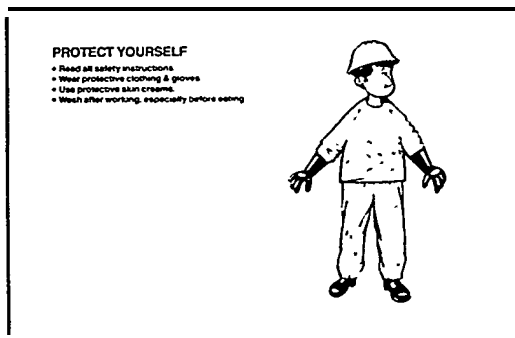
## HOW CAN A PAINTER BE PROTECTED FROM HEALTH HAZARDS?

The most frequent health hazards associated with the application of coating materials are skin rashes. The high vapor concentrations of the amines may also be irritating to the eyes, mouth, and nose. Serious lung damage has been reported. However, these conditions do not affect the entire body. They remain local and are similar to allergic reactions.

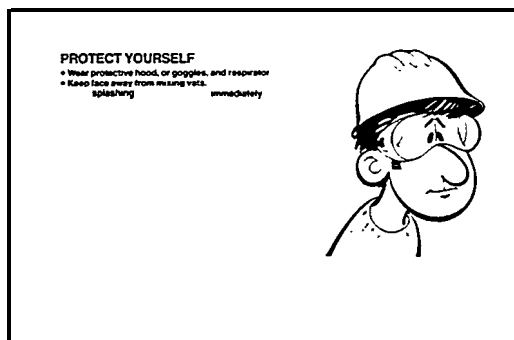
Overexposure to some solvents can produce serious sickness. This may include headaches, nausea, choking sensations, disturbed heart action, or injury to liver, kidneys, or heart.

A painter can be protected by following these rules:

1. Read the manufacturer's data sheet for safety instructions of the coating material.
2. Wear protective clothing and gloves.



3. Apply protective creams to any exposed parts of the body.
4. Wash immediately after working, and especially before eating. The application of cold cream or another lanolin ointment can prevent the skin from drying out
5. Use a protective hood or goggles and a respirator.



- 
6. Keep face away from mixing vats and avoid breathing vapors.
  7. Use low speed mechanical mixers and avoid splashing. Clean up spillage immediately.
  8. Obey warning signs. They have been placed in the work area for your safety. Examples are NO SMOKING: NO EATING IN AREA: RESPIRATORY EQUIPMENT TO BE WORN IN THIS AREA: PROTECTIVE CLOTHING TO BE WORN IN THIS AREA.
  9. Work only in areas where there is sufficient ventilation to remove hazardous concentrations of vapors. This is especially important in confined work areas, such as cargo tanks.
  10. If the skin comes into contact with irritating materials, wash with soap and water soon after. Do NOT wash with solvent. The solvent will penetrate the skin and carry the toxic material with it.

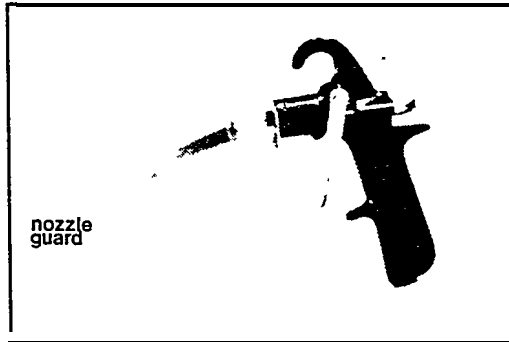
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AVOID MECHANICAL HAZARDS  
RELATED TO SPRAY  
EQUIPMENT

Improper handline or unsafe equipment may cause safety hazards. A painter can be protected by observing the following rules.

1. Check the safety release valves on pressure equipment regularly.
2. Check all hose connections and fittings to make sure they are tight and not leaking.
3. Check hoses for kinks or abrasion that may develop into a dangerous rupture.
4. Handle carefully all hose connections, joints, and seating surfaces on the spray gun to prevent damage.
5. Do not disconnect any part of the spray equipment until the pressure has been released.
6. Never change nozzles without shutting off the pump and releasing the fluid pressure.

- 
7. Use the special nozzle guards provided for airless guns.



8. Never point a spray gun at any part of the body, especially an airless gun. This can cause serious injury, or even death, if the skin is penetrated.



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#### REDUCE DANGER FROM FIRE AND EXPLOSION

In applying paints and coatings, there is a potential danger from fire and explosion. A paint's flammability is determined by its flash point. This is the temperature it can reach before catching on fire when a flame is applied. Paints which contain the stronger solvents, xylene and toluene, have low flash points and are very flammable.

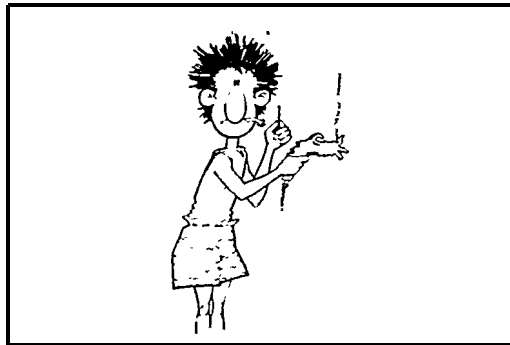
The possibility of an explosion with a solvent depends upon the amount of solvent vapors in the surrounding atmosphere. Three things are required for an explosion to occur: a spark, oxygen (air), and fuel (which is the solvent vapor). There must be the right mixture of fuel and oxygen when the spark is introduced for the explosion to occur.

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If there is too much fuel in the mixture, there is not enough oxygen present for an explosion. If there is too little fuel present, it means there is not enough for an explosion to occur.

Follow these safety rules when handling flammable paint materials.

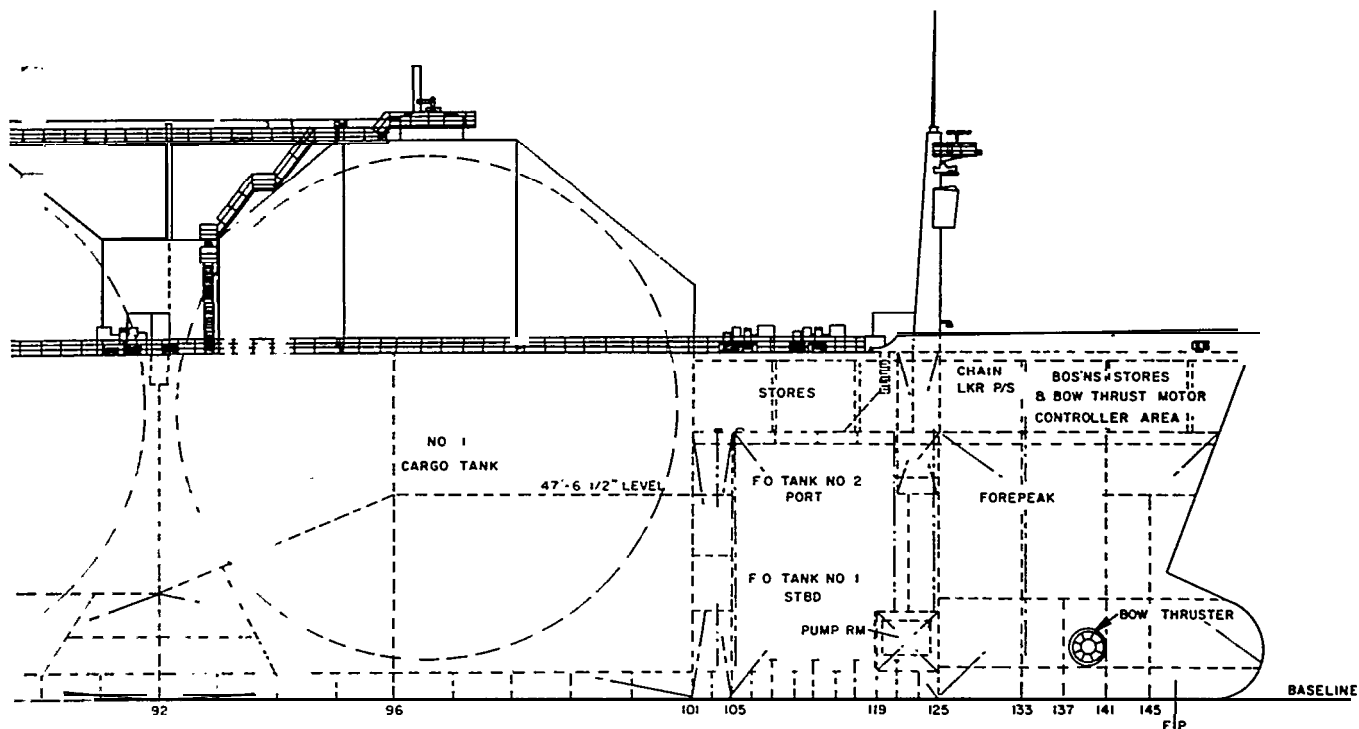
- Avoid storing or using paint in an area with a temperature that is near or above the flash point.
- Spray units and their components must be grounded to prevent dangerous static sparking. Make sure the electric supply circuit is grounded as well. If spraying with a flammable material, the object being painted as well as the spray gun must be grounded to prevent static electricity from causing a spark.
- Do not spray solvent under pressure through the gun nozzle tip. An explosion or fire could result from static electricity build-up in the presence of flammable vapors. Always remove the nozzle tip from the gun before cleaning.



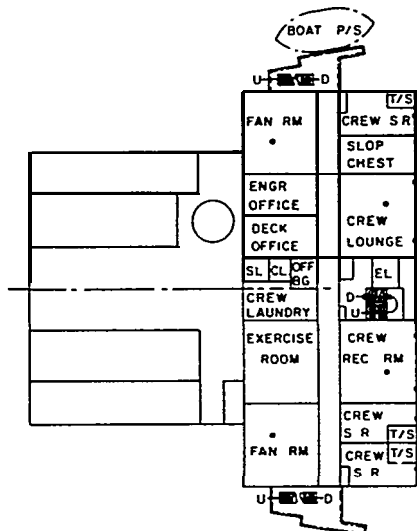
Ž Never smoke while mixing or applying paint. All sources of flame must be removed from the area where paints are mixed or applied. Extinguish all pilot lights on water heaters, furnaces, or other equipment in the area. Welding should not be permitted in the same area.

- In confined areas, use only vapor-proof and explosion-proof electrical equipment.
  - Do not work in an area when the air is not clear and free of excessive solvent odor.
- Ž Mix all materials in a well ventilated area, away from sparks and flame.

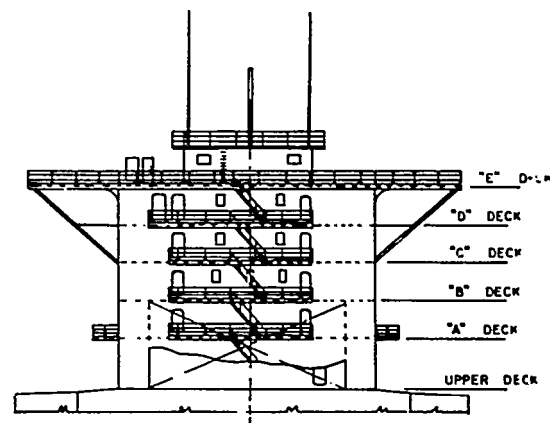
# GLOSSARY



PROFILE



1ST LEVEL  
DECK HEIGHT = 10'-10"  
3 CREW S R



VIEW OF HOUSE  
LOOKING FWD

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## GLOSSARY

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ABRASION	being worn away by rubbing or friction
ABRASION RESISTANCE	resistance to being worn away by rubbing or friction; related to toughness, rather than the hardness of a paint film
ABRASIVE	the material used for abrasive blast cleaning, such as sand, mineral grit, steel shot or steel grit
ADHESION	bonding strength; the attraction of a coating to the surface to which it is applied
AGITATE	to stir or shake
AIR COMPRESSOR	a separate piece of equipment <b>in spray systems which</b> draws in air and compresses it, thus providing high pressure and volume of air required for abrasive blasting and spray painting
ALKALI	a substance such as lye, soda, or lime that can be highly destructive to paint films; caustic
AMBIENT TEMPERATURE	room temperature or temperature of surrounds
ANCHOR PATTERN	a rough pattern of peaks and valleys caused by abrasive blasting which improves the ability of the paint to bond to the steel surface
ANTI FOULING	coating containing toxic ingredients, <b>such as cuprous oxide</b> , applied to shipbottoms to prevent marine growth
ATOMIZE	to reduce a liquid to a mist; to break a stream of paint into small particles
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BINDER	the resin, or film-forming ingredient in paint, that binds the pigment particles together
BLAST PATTERN	the surface area hit by the abrasives: the closer the <b>nozzle is</b> held to the surface, the smaller the blast pattern
BONDING	a mechanical attraction between two surfaces, such as two coats of paint or paint and a substrate; the mechanical "holding effect" between paint and steel, for example, may be increased by roughening the steel surface
BOUNCE-BACK	spray paint rebound from the surface
BOXING	manual mixing of paint by pouring back and forth from one container to the other

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BREAKDOWN CHARACTERISTICS	the extent to which an abrasive pellet is damaged after striking the work surface; related to the recyclability of an abrasive and degree of dusting
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BRONCHITIS	an inflammation of the mucous lining of the bronchial tubes
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BURNISH	to make shiny by rubbing or polishing; burnished metal is a poor surface for paint bonding
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BURR	a raised "splinter" on a metal surface which will interfere with coating performance
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CAMOUFLAGE	the process of disguising or changing the appearance of a ship to blend into the background
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CATALYST	curing agent; hardener
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CFM	cubic feet per minute; the capacity, or the air volume, of an air compressor is measured in CFM units
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CHALKING	loss of gloss; powdery surface, usually due to the weathering of paint films
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COBWEBBING	a stringy thin spray pattern; this paint film defect is frequently seen in hot weather when a fast solvent is used in chlorinated rubber or vinyl paints; the solvent evaporates before the paint is deposited resulting in "fingers" or "cobwebs" of paint being delivered to the surface
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CONDENSATION	to become more dense, as a vapor into a liquid; moisture may appear on a surface as an almost invisible film or as water
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CONTAMINANT	dirt, oil, grease, loose rust, paint, or mill scale, which must be removed from the surface for paint to bond securely
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CORROSION	gradual destruction of a material, such as metal, due to interaction with the environment
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CURING	hardening; setting up
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DEADMAN VALVE	shut-off valve at the blast nozzle, which allows the blaster to start or stop the abrasive flow
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DEFECT	imperfections in the paint film which can lead to early paint failure
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DEHYDRATION	loss of moisture or fluid; to dry out
DERMATITIS	skin irritation or rash
DETERIORATION	the gradual decay of a material; as a paint film ages with exposure to sun, rain, and chemicals, its protective qualities deteriorate and corrosion can begin
DEW POINT	temperature at which moisture condenses
DISPERSE	to break up and distribute in different directions; in mixing a paint, the pigment must be evenly distributed
DRY TO HANDLE	time interval between application and ability to touch a painted surface without damage
DRY TO RECOAT	time interval between application and ability to receive next coat satisfactorily

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EROSION	wearing away of a surface; heavy chalking tends to accelerate erosion of a paint film; water <b>flow over a ship's propeller causes metal erosion</b>
EVAPORATION	the <b>release of solvents from the paint fluid into the atmosphere</b>

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FAILURE	loss of adhesive and/or protective qualities of a paint film which can no longer serve its function as a barrier to corrosion
FILM THICKNESS	depth of applied coating, usually expressed in mils (metric: microns)
FLAMMABILITY	ability to burn
FLASH POINT	the lowest temperature at which a flammable material will ignite if a flame or spark is present
FOULING	growth of attachments, such as weeds or barnacles, to hulls of ships or other marine structures
FRICTION	the rubbing of one object against another

GENERIC	a class or group; generic paint types take their name from the kind of resin in the formulation -- alkyd, epoxy, etc.
GLOSS	ability to reflect; shininess; luster; brightness
GROUNDING	dissipation of electrostatic charge
HORSEPOWER	a unit for measuring the power of motors or engines (equal to a rate of 33,000 foot-pounds per minute); abbreviated HP
HYPODERMIC NEEDLE GUAGE	a guage inserted into the blast hose close to the nozzle to measure air pressure at the nozzle
HYDROBLASTING	water blasting; the use of water pumped at extremely high pressures to remove unwanted materials from a surface
IMMERSION	completely covered by water; submerged
IMPACT	striking together; collision
IMPERMEABLE	not permitting the passage or penetration of moisture, air or other substance
INDUCTION TIME	the length of time that a mixed catalyzed paint must stand before it is ready to apply (also called "setting up" or "sweating in" time)
INTERIOR DIAMETER (ID)	measurement across the inside width of a hose, usually expressed in inches
IRON OXIDE	a combination of iron (Fe) and oxygen (O <sub>2</sub> ); "rust" is a form of iron oxide
MIL	one one-thousandth of an inch; .001"; 1/1000 inch
MILL SCALE	layer of iron oxide, bluish in appearance, formed on the surface of steel during manufacture
MISTCOAT	a heavily thinned coat of paint (approximately 90% solvent) applied in a thin film (approximately .5 mil) to "re-flow" the previous coat of paint; also used on porous films such as inorganic zinc to seal pores for topcoating

ORIFICE	opening or hole, as in a spray gun fluid tip
OVERSPRAY	fluid that is lost by missing the surface to be painted
PASS	motion of the spray gun in one direction only; one stroke
PEEN	to hit the surface leaving rounded indentations, providing a wavy anchor pattern
PERMEABLE	allowing passage or penetration
PIGMENT	paint ingredient used mainly to impart color, hiding power, and protection
POTABLE WATER	drinkable water
POT LIFE	the time after the catalyzed paint has been mixed during which the material is usable
PRIMER	the first of two or more coats of a paint system; usually a rust-inhibitive coating when used over ferrous metal
PROFILE	surface contour of a blast-cleaned surface as viewed from the edge; improves the ability of the paint to bond to the surface
PSI	pounds per square inch; a measure of force, such as the air pressure at the blast nozzle
PSYCHROMETER	an instrument with wet and dry bulb thermometers for measuring the amount of moisture in the air
RESIN	a major ingredient of paint which binds the other ingredients together and imparts protective properties
RESPIRATOR	a device worn over the mouth and nose to prevent inhaling harmful substances such as dust, solvent vapors, fumes, etc.; respirators may be cartridge, filter, or air-fed

SHELF LIFE	maximum amount of time in which a material may be stored and remain in usable condition
SILICOSIS	a type of respiratory disease caused by silica particles lodged in the lungs
SKIDDING	a paint roller sliding across a surface leaving roller tracks; caused by too little or too much paint on the roller cover
SOLVENT	liquid ingredient of paint, the function of which is to dissolve the resin so that it may be applied easily
SPRAY FAN	shape of the spray pattern
SPRAY PATTERN	description of the shape and size of the paint mist when it strikes the surface; varies from a circle to a long narrow oval
SUBSTRATE	surface to be painted
SURFACE PREPARATION	all operations necessary to prepare a surface to receive a coating of paint
THINNER	liquid added to a coating to adjust consistency
THIXOTROPIC	a gel which becomes a liquid when stirred but gels again on standing; "false-bodied"
TOOTH	surface roughness which improves the ability of the paint to bond to the surface
TOXIC	poisonous
TIECOATING	application of a thin adhesive coat to aid in the bonding of two coats of paint
VEHICLE	liquid portion of a coating; made up of binder and solvent
VENTURI NOZZLE	nozzle with a tapered lining shape; it increases abrasive speed and creates a larger, more even blast pattern
VISCOSITY	a measure of how fast or how slow a liquid flows
VOLUME SOLIDS	the percentage of the total volume occupied by non-volatiles (paint solids)
WELD FLUX	deposits of the fluxing (flowing) agent which, when left on the metal around a weld seam, may cause paint adhesion problems
WELD SPLATTER	beads of metal scattered next to the weld seam; these interfere with paint adhesion and should be removed

